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Forthcoming Event.

AUGUST 6, 7, & 8.

British Foundrymen's Association—Annual Convention, to be held at Cardiff.

NOTES AND COMMENTS.

Should Iron be Poured Hot?

It is quite customary for experienced foundrymen to differ diametrically on the question of pouring temperature. The difference of opinion is so great that a boon would be conferred upon the ironfounding industry if someone of unquestioned authority were to come forward and establish the real truth beyond all doubt. It is generally recognised that if the mould and cores are not carefully constructed of suitable material or reinforced by specially refractory sand at those parts where the metal strikes on entering the mould, very hot iron cannot safely be used. If the moulding mixture employed be not hard or refractory or porous enough, the mould or gates will break or scale, or the casting will be blown. If the cores are made of an improper material they will expand beyond the limit that can be provided for and the casting be spoiled; or if unsuitable core bonds are used the amount of gas generated will be more than the vents, however numerous and well arranged, can conduct away. The hotter the iron the greater the liquid shrinkage as the iron cools, which necessitates special precautions as regards running and feeding. The hotter the iron the hotter the job for the moulders; and on a warm summer's day the task of pouring large castings with very hot iron is an uncomfortable one, especially where there are pouring, rising or feeding basins of large capacity and area, and the moulders have to stand round and pump the casting. Without specially constructed moulds it is at any rate very risky to pump deep, heavy castings from top gates.

But, against all this may be set the claim that the hotter the iron the more perfect the solution or combination of its different constituent elements, and more especially the more perfect the solution of gases held by the iron. In connection with the foregoing it should be understood that the more stable solution of the different chemical elements in hot iron is not due so much to actual combination as to the hindering through molecular movement of the separations and segregations which must take place as iron cools. The hotter the iron when put into the mould the more rapid the cooling process down through the range of temperature during which the separation of graphitic carbon in comparatively large flakes occurs. The hotter the iron when put into the mould, and, *ipso facto*, the greater the liquid shrinkage in the mould, the denser and more solid the casting, if the casting is properly supplied with gates, risers and feeding heads.

It is evident, then, that the cooler the iron the easier for the moulds and the men; the hotter the iron, providing the moulds and cores are properly prepared, the better the casting; so that for good castings iron should be poured as hot as it can be got. But something depends on the nature of the goods being turned out. Where high density and freedom from internal sponginess, cavities or blowholes are required, hot iron is undoubtedly to be preferred. Light, thin castings, requiring little strength, but fine, unbroken surfaces and a clean,

smooth skin, can be cast satisfactorily with dull iron, providing it is siliceous and phosphoric enough. If the moulders cannot construct their moulds to withstand the inrush of hot iron they should be given better materials. Sand, facings, etc., used in the steel foundry are equally available in the iron-foundry.

Liquid Shrinkage.

As to liquid shrinkage, this can only be dealt with by means of larger gates, coupled with more head-pressure. Molten iron which has been allowed to cool down in the ladle has already set free a good deal of graphitic carbon. The quantity of this carbon largely governs the expansions which take place during the solidification of iron. The higher the free carbon the greater the expansion, so that the total liquid shrinkage will vary according to the amount of free carbon formed. This is the explanation of the much lower liquid shrinkage in soft than in hard irons. It is therefore clear that when iron is cast very hot special arrangements must be made so that all sources through which the casting can receive fresh supplies of liquid metal are large in area and kept open until the liquid shrinkage in all parts of the mould has been met. It is in the neglect of this precaution that castings poured with hot iron generally go wrong; the arrangements for feeding are insufficient.

From the foregoing it is clear that where an important casting of heavy section has been cast with iron as nearly as possible at its maximum temperature as delivered from the cupola and thus brought down quickly in the mould through that range of temperature during which the carbon separation takes place, the casting will be of high density in all parts, providing the feeding has been carefully attended to. This applies to the comparative absence not only of graphitic carbon in large flakes, but of freed gases and of the phosphoric, sulphuric and other segregations. The value of high-quality pig-iron used in making castings can be entirely lost through casting with dull metal, and castings are often to be seen made with a mixture containing large percentages of the finest charcoal iron in which the structure is entirely broken up by frequently occurring localised deposits of large-grained graphitic carbon. The effect of graphitic carbon on the density of cast iron cannot be too strongly insisted upon. By reducing the total amount of graphitic carbon in cast iron by 1 per cent. (say from 3.25 per cent. to 2.25 per cent., a reduction quite easily possible), the specific gravity of the iron would be raised 2.5 per cent. Further, as the practical moulder will also observe, the hotter the iron when put into the mould the more readily will any solid impurities rise to the top and be gathered in the sinking-heads or risers provided for that purpose. Detached sand or facing material from the mould, particles of slag or dirt, or segregations of free carbon are lighter than the metal, and so long as the iron is fluid these will rise up freely through it. On the contrary, with iron which has been allowed to cool down in the ladle, such impurities are correspondingly held fast and cannot subsequently rise up through the metal and out of the casting. The man who casts heavy castings with dull iron will get castings solid and clean in the outer parts and with a smooth skin, but of doubtful solidity in the interior, and the man who casts with hot iron will get a casting solid in the interior but possibly with a rough skin and some superficial blemishes. It is clear which is preferable from the engineer's point of view.

Hot Metal for Machinery Parts.

If a solid casting of heavy section be cast with dull iron, the liquid shrinkage will, as stated, be small; there will not be the same pull from the interior on the walls of the casting as there would be with hot iron. Consequently the walls will set solid, but the interior may be spongy or full of cavities. This character of casting, tight outside but spongy within, would be dangerous in the case of certain important machine components, as for example heavy cylinder work for hydraulic, high-pressure steam or high-power gas or oil engines. The principle should be to build up a casting as strong and as dense as possible at the centre of the heavy sections. If the iron be poured very hot the casting will draw powerfully from the sides in the direction of the centre, and so long as the draw continues the sides will continue to give way and furnish metal to the interior; and if the gates and feeders are properly arranged the whole of the metal supplementary to the first pouring operations necessary for the building up of the casting from within outwards can be supplied. Should there be imperfections they will be prominent on the outer surfaces of the cylinder and will not go down under the skin, unless mistakes have been made other than those connected with the pouring temperature and the gating and feeding.

In conclusion, we might repeat the opinion expressed by the foreman of a large Continental foundry engaged in the manufacture of crude-oil engines and in which four to five tons of cylinders are cast daily. This gentleman mentioned the use of hot iron as the first and foremost amongst the conditions which make for success in this class of work. The testimony is a valuable one, and there are foremen who are struggling with difficulties and sometimes almost overwhelmed with them, who would do well to lay it to heart. We might categorise the principal factors upon which success in the casting of cylinders and other important machine components of heavier and more complicated type depends as follows:—(1) A good-working cupola; (2) hot iron; (3) quick pouring through a large and properly arranged gate area and ample head pressure; (4) a suitable iron mixture.

Forthcoming Foundrymen's Convention.

This month witnesses an important function in the session of the British Foundrymen's Association, viz., the Annual Convention, which is this year being held at Cardiff. The selection of Cardiff for this year's gathering place is a happy choice, since the Convention will witness the election of Mr. C. Jones (President of the Cardiff Branch) to the Presidential chair of the parent Association. Mr. Jones has been a strenuous and valuable worker for the Association, and the honour of Presidency has been well earned. During the two years under the presidency of Mr. Percy Longmuir, the Association has made excellent progress, and while much praise is unquestionably due to the loyal support he has received from the officials and members, it must be acknowledged that the presence at the head, of a man who is well recognised as an earnest worker, both in research and on practical lines, has been a great help. Under the guidance of Mr. Jones the practical side of the Association's work in particular should receive a further stimulus, and we look for a prosperous two years ahead.

It is a promising sign to find amongst the Papers of scientific and practical interest which are to be presented and discussed at the coming Convention, one which takes up in earnest the important question of the education of foundry apprentices. It may be that forceful handling of the question by the British Foundrymen's Association will give a timely lead to others, and it is to be hoped that the members will not hesitate to put forward any suggestion that contains a point of value.

The Moulding of a Gas-Engine Bed.*

By J. G. Robinson.

The particular type of bed casting I have chosen for purposes of illustration is intended for a horizontal gas engine, and the cylinder jacket constitutes a part of the casting. The actual example taken is

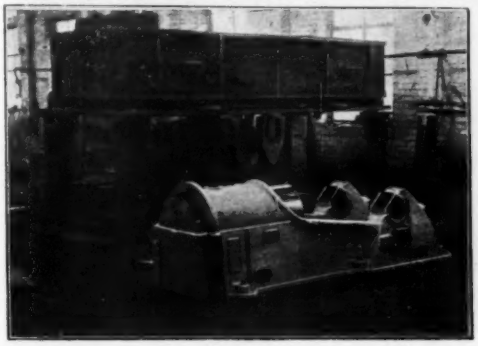


Fig. 1.

that of an 80-b.h.p. engine, the overall dimensions of which are 11 ft. by 4 ft. 4 in. by 3 ft. 6 in.

Fig. 1, illustrating the pattern, which is of skeleton design, shows where the core prints are necessary, the joint on the cylinder body, and the loose facings and beadings.

Before proceeding with the description of the actual moulding operations it will be perhaps advisable to describe the tackle used. The particular part of the foundry floor prepared for making beds is reserved for that purpose only. The mould for this casting is made in dry sand, and only a middle box part 2 ft. 6 in. deep and a top part are used for this mould. The pattern is bedded in the foundry floor, which allows of any depth of pattern being used in the same place. The two box parts are shown in Fig. 1 on the stan-

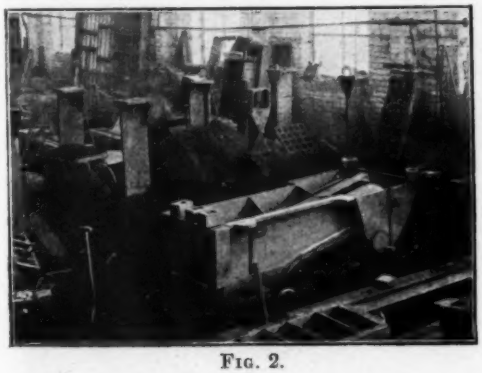


Fig. 2.

chions by the side of the pattern. These stanchions will be referred to later.

The use of a bottom part of a moulding box renders it possible to bolt securely together all the parts so as to resist the pressure exerted when the metal is poured into the mould, but if the bedding takes place in the floor it is necessary either to weight the top part or make some other provision to resist this pressure.

In this particular case 12 tons would be required for weighting down, so binders are used instead. They are fixed in the floor sufficiently low down to clear the deepest pattern used, and are connected to similar binders across the top part of the box, thus enabling the various parts of the whole mould to be firmly bound together. These bottom binders consist of three cast-iron bars, 8 in. by 5 in. in section, placed at equal distances from each other along the box, and are of sufficient length to allow the ends to project beyond the sides of the widest box used. They are well bedded down, as they are permanent fixtures. From them packings are brought up to the bottom edge of the middle box part. These packings are plain castings 5 in. square and 18 in. long. Being loose they can be moved along the binders to suit the width of any box used. Any variation in depth can be made by placing other packings on the top of these. The bottom edges of the binder ends are rounded, and links of $1\frac{3}{4}$ in. round iron are placed under them

Fig. 3.

which reach upwards to the level of the foundry floor, thus forming the connections for the hook bolts. When the whole of the box is fixed, iron meets iron throughout, and the various parts are firmly bolted together.

In the first place, after the binders have been fixed, a coke bed is made immediately below the part where the cylinder body comes. This being the deepest part of the casting, the sand underneath and the coke bed are seldom disturbed. The arrangements up to this point remain permanent, as previously explained, for all sizes of beds moulded in this particular place.

The actual pattern to be used is carefully measured so that its deepest parts and position in the box may be ascertained. This having been done, a cast-iron packing is fixed so as to come directly beneath the print for the cylinder body core at the back end. This prevents crushing or sinking when the core is fixed. At the front end of the cylinder a similar support is used which, however, extends right across the whole width of the moulding box and is used later for bolting down the cylinder core at that end. These packings are so fixed that when the pattern rests on them, the top of the pattern is level with the top joint of the moulding box.

* Paper presented before the Lancashire Branch of the British Foundrymen's Association.

Preparation is now made for bolting down the loose body of sand which forms the oil slide or crank race part of the casting. This will be explained later. At this stage a square wrought-iron bar is placed across the box near the centre and another bar down the centre of the mould so as to come under the box end and the first bar. Facing sand is now placed at the points where the bearing necks and cylinder body come, and the pattern which is jointed along the centre line of the cylinder but screwed together for the first operation is fixed, levelled, and weighted, ready for the first ramming. Ramming now proceeds round the bearing necks and lengthwise towards the cylinder body.

For convenience in ramming under, this is done before the box part is put on. The box part is now placed in position, care being taken to see that all the cross bars for bolting down the cores either touch the bottom edge or are wedged under. When fixed there is a certain amount of sand all round the bottom of the box sides and ends which has been disturbed from the previous cast. This is all rammed firm both inside and round the outside of the box so that all the sand round is again part of the foundry floor.

Before the necks are covered, flat irons are placed along the print up to the face of the pattern, thus ensuring a safe guide which is not easily disturbed or broken during the fixing of the cores. Ramming now continues round the necks until the facings are firmly bedded, and the screws can be taken out, leaving the

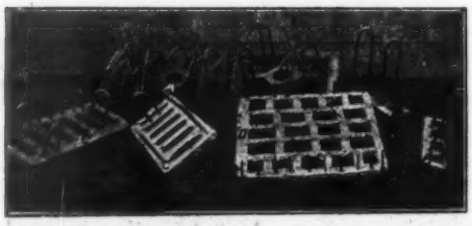


Fig. 4.

facings loose for drawing in after the pattern is removed. At this stage a coke bed is laid across the mould under the centre of the oil slide to take the vents from that part of the mould. This vent is carried through the top part of the box by means of a tube placed close to the box side (see Fig. 2).

The drying is done by means of portable stoves fixed at each end of the box, and provision is now made at the crank bearing end for the hot blast to enter the mould. This is done by placing two tubes into the prints for the sight-hole cores in the oil well of the crank bearings. Wrought-iron ferrules are placed round the prints. These protect the sand around from being burnt by the hot blast, and also ensure a good seat for the cores later. A joint is made across the box and the tubes laid from the sight-hole prints.

Bricks are placed round them and the whole lot is covered by a plate with a hole in the centre. This then really forms a blast box. A connection is made by placing the tube over the hole in the plate to reach to the top joint. Ramming then continues up to a point where it is possible to make a false joint along the centre of the beading.

The pattern is now withdrawn, leaving the bottom half of the cylinder body, the beadings and loose facings for the necks of the crank bearings in the sand and a false joint is struck off from the cylinder end right to the other end of the pattern. Since in the actual moulding operations, the box part is placed in position before this joint is made, a view showing the joint, the hot blast entrance and the ingates is prevented. To overcome this difficulty, the box was removed to give the view shown in Fig. 3. This joint is necessary for drawing in the beadings, which are much thicker than the sides of the bed pattern. It also leaves more room for stamping in the name plate which has to be done later, and also makes more convenient the finishing of the deeper part of the mould, as a man can work from this joint face much

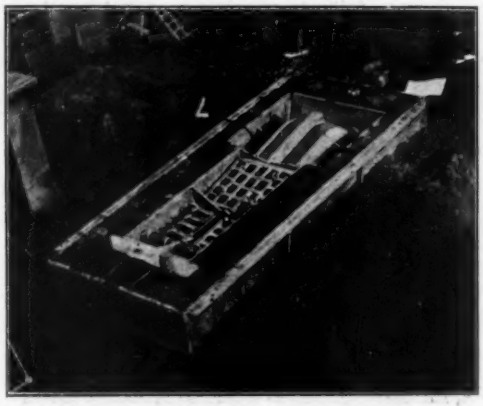


Fig. 5.

easier than when reaching down from the top joint of the box.

At this point the writer must recall to notice the body of sand previously referred to as the oil slide part of the casting. This is really the crank race, which extends from the cylinder end to the other end of the bed. It will generally have been noticed that when a gas engine is at work a certain amount of oil drops from the connecting rod crank bearings, and the inside of the cylinder into the hollow part of the bed and is drained off at one end. This hollow part is for this reason referred to as the oil slide. The body of sand or, as it may be termed, the oil-slide core, will be seen later lifted away from the mould. To carry this

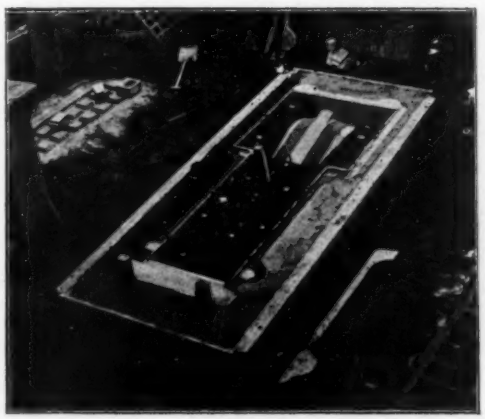


Fig. 6.

the grid (A), Fig. 4, is used. These grids are always kept at least 2 in. clear of the casting all round, to allow for contraction. This is important, as cases have been known where the casting has been cracked owing to the grids being too large. It will be noticed

that the grid is plain and rectangular, having lifting staples and pieces of wrought iron cast in it. These can be bent to follow the rounded part of the core. At two places along the centre provision is made for the hook bolts to pass through to the bar used for bolting down, and mentioned previously. The joint is now covered with parting sand and the grid placed straight on.

There is no sand underneath for bedding, so that later when the core is replaced there is no fear of any

FIG. 7.

dropping off. Provision is now made for the ingates. These, which are 4 in. by 1 in., follow the section of metal in the cylinder body on each side from the centre and are placed against the part of the pattern left in the sand. The pattern is now replaced, and the part referred to as the oil slide core, is rammed up in the ordinary way. The pattern being of skeleton design, this is an easy matter, as there is plenty of room between the stays to get material through and use a rammer.

As the lifting grid has purposely been kept small, a few gaggers are placed along the edges to secure a clean lift. About 6 in. from the top a good layer of

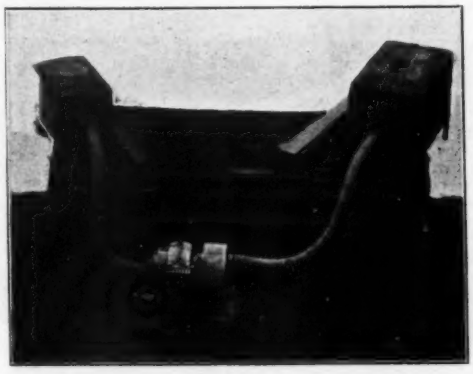


FIG. 8.

coke is inserted. When rammed up to the top it is strickled off to follow the shape of the pattern, thus forming the joint on to which the top part is rammed. Before this is finished the whole of the top is well vented into the coke mentioned. At this stage the joint is made. Although this is only a small matter, a lot of finishing is required when the core is replaced, if it is not carefully made. Wet parting sand is placed on the joint as, owing to its steepness, dry sand would not stick.

The down runners are now fixed to connect with the in-gates. These are placed against the back end print for the cylinder core. When this core is fixed later it forms one side of the down runner and covers the top of the in-gates. Two wrought-iron plates are now fixed, which reach from the end core print to the box end. An open space 10 in. wide is left between them for the hot blast to enter at this end of the mould.

The outside of the pattern now receives attention. Facing sand is placed round the beading and a ram brought up level with the top edge of same. Between this and the sides of the box, the backing sand is well flat-rammed to make it perfectly firm, as this is the point most liable to straining. Facing sand is again placed over the beading, which is well ironed to carry the over-hang before filling for the next ram. Ramming now proceeds to within about 8 in. of the joint on the outside of the pattern, when this is left and the inside rammed as follows:—A layer of facing sand is placed on the pattern and the grids C, C, Fig. 4, fixed in position over the parts covering the cylinder body. One side is bedded on the sand nearest the centre, and the other side containing the straight wrought irons is packed up level from the bottom of the pattern by means of a piece of straight iron (see Fig. 5).

Gaggers are now placed along the thin bottom part of sand and hung on to the grid, and about a 3-in. layer of sand is rammed and another double row of gaggers fixed. This is necessary on account of the increasing width upwards towards the crown of the

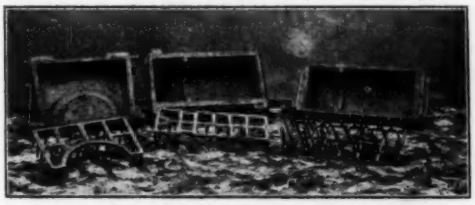


FIG. 9.

rounded part. Another ram and another row of gaggers covering a still greater width brings the sand up to the top of the grids.

Beyond the rib L (Fig. 5), a wider grid D (Fig. 4) is used, which covers the full width of the pattern. Before this grid is placed on, the skeleton part of the pattern which has a sand face is covered with paper to ensure a clean lift. This part is now gaggered and rammed, as previously explained, on the other grids. The hollow parts over the crank bearings are next rammed up. A layer of facing sand is placed in the bottom and the grids B, B, are bedded in. These grids serve the double purpose of lifting the pocket of sand and also of forming a firm top for holding down the cores of the oil well in the crank bearings. From these iron grids packing, or as they are termed in some foundries, "scotchings," are brought level with the top of the pattern.

Before proceeding to ram up the sand in the pockets, a couple of weights are placed at each side to form a backing to ram against, as the centre part at this end of the bed is not rammed up at present. Also, the highest part where the oil slide comes up to the top cannot be covered with a grid, so these parts are left bare until the top part of the box is put on, when they are picked out with gaggers. These weights having been fixed, the sand in the pockets is rammed up. A few gaggers are used in the bottom, the remainder being strengthened with straight irons placed diagonally. This method allows for contraction. These pockets, and also the parts under the other grids, are now well vented with a vent wire, packings are placed

on the top of the lifting grids to the level of the top of the pattern and a few cokes are placed next to the grids to form a connection with the vents just mentioned.

A connection is carried from each bed of cokes to the top of the pattern, and continued through the top box after it is placed in position. Ramming now

Fig. 10.

proceeds on the inside up to the top of the pattern, after which the outside again receives attention. This, which was left incomplete about 8 in. down from the joint, is now rammed up to within 2 in. of the joint, after which the oil tray, which is a loose part of the pattern running round three sides of the bed, is fixed in position and facing sand tucked under and rammed firm with a small rammer.

These loose parts are now removed, and the small body of sand which stands up from the remainder of the mould is sprigged with a double row of sprigs. These can be seen in Fig. 6.

The sand which is disturbed by sprigging is made good with the fingers, and facing sand is sieved all along these parts. The loose parts of the oil tray are now replaced, and bedded down to their proper place. The sieved sand allows this to be done easily, and makes a good finish to this part of the mould. The

Fig. 11.

remainder of the outside is now rammed up to the joint, the joint struck off from the outside of the pattern to the box part and parting sand sprinkled on.

All the staples in the lifting grids are now bared, and hook bolts of suitable lengths to reach through the top part of the box are attached. The packings from the grids are all chalked so that they can be plainly seen after the top part has been placed in position. Paper is placed over the sand part of the skeleton pattern. The down runners are withdrawn, and the holes covered with pieces of sheet iron which protect the edges while the top is being rammed. This is necessary, owing to the fact that a broken runner is used. The box pins are now fixed in the lower part. Owing to the depth of the lift these pins are long, and in order to prevent them being damaged are removed when the mould is ready for casting. The top part of the box is now placed on, and the packings previously mentioned wedged from the box bars. Fish-plates are fixed over the hook bolts from the

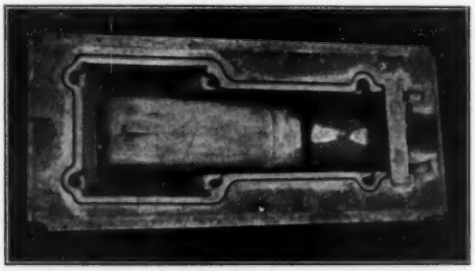


Fig. 12.

lifting grids and the whole bolted firmly to the top part. The fact that iron meets iron throughout renders this possible.

Facing sand is now placed on the parts left bare, and gaggers are fixed. The runner pegs and also five risers are fixed, and pegs to connect with the vents from the cokes over the top of the lifting grids. The whole of the top is now rammed up with the exception of the centre sections of the last space at each end of the box, which are left open for the hot blast connections. The gaggered parts are well vented with a wire, although this operation is not necessary elsewhere, all other parts being connected with cokes. All the ramming now being complete, the top is lifted off and placed on stanchions by the side of the mould.

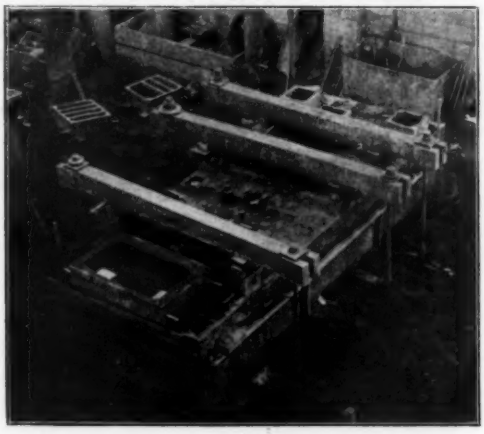


Fig. 13.

These stanchions were shown in Figs. 1 and 2. These are sufficiently high for a man to get underneath to do all the finishing work.

In this way, turning-over, which is rather a difficult job on account of the long hanging part of sand, is dispensed with. The down runners are now replaced, and the sand which has been filled into the space left originally for drying is dug out. The skeleton parts are strickled out to leave a space, the joint brushed off and watered, and the loose parts forming the oil tray withdrawn. The main body of the pattern is

now drawn. This being lightly made, very little rapping for loosening can be done.

Lifting hooks are fixed to the straps provided for this purpose, and a bar is threaded through the two at each end across the pattern. On the centre of these two bars, screw hooks are attached and hung on to the crane chains. Before any lifting is done by the crane, the pattern is raised a few inches by means of screw hooks. These having right- and left-hand threads, a steady draw is effected as the outside frame is pulled round. The pattern being well tapered, is, after being raised a few inches clear of the mould all round, then lifted out by the crane.

The sand over the staples of the grid in the oil-slide core is dug out, and hooks are attached for lifting this core away. Before this core is lifted, two pieces of iron are driven in the top and levelled. This is necessary, as the false joint is at an angle. Later, when the core has to be replaced, and before it is lowered into position, a spirit level is placed on these two pieces of iron, the correct angle of the core being obtained by means of screw hooks (see Fig. 10). This prevents any crushing on the soft joint.

This core is lowered in a convenient place for finishing, and holes are dug out in the false joint down to the bars underneath the box for bolting down the core, to match the holes in the lifting grids. Over these holes flat wrought iron plates of fairly large size are placed. These, in addition to covering the holes, prevent the face of the joint being damaged by the moulder standing on it for finishing. The work of finishing the mould now proceeds on all parts above the centre of the cylinder body where, as previously stated, the pattern is joined. The lower part of the cylinder which is left in the sand forms a platform to work from, and also prevents any loose sand from getting into the lower parts of the flanges. Where necessary, sprigging is done round the loose facings and beadings. These are withdrawn, and where possible the small cores are fixed, and the sand made good round them. The remaining part of the cylinder body is now withdrawn, and a board laid across from the false joint to the open space at the end left for the hot blast. This forms a platform to work from to finish the deep parts.

The parts just in front of the ingates are well face-sprigged to prevent scabbing. All the work of finishing so far as possible is done with a cork rubber, the finishing tools being used only where absolutely necessary. The top part and oil-slide core are finished in like manner, and all is now ready for wet blacking. This blacking is applied fairly thick, and finished with the tools. After all the parts of the mould have been finished, the name is stamped into the sides of the mould by means of a name plate. The correct position for this on the side of the mould is measured off. At one end a flat file or other piece of flat iron is driven into the side of the mould at a depth suitable for the bottom edge of the name plate. On this a parallel straight-edge is placed, and a spirit level used to find the correct depth of the other end. Another file is then driven in. The name plate is now well brushed over with paraffin, plenty of which is used, parting sand being then dusted over it. It is now carefully placed, so that its bottom edge rests on the two files which support its weight, and determine its position. The bottom edge is placed just at the right distance from the mould face, so that when the plate is rotated on this edge the whole face of it touches the mould at the same time. This is now stamped in by a few smart blows with a hammer on the wood blocks provided for the purpose. The name plate is then drawn off, and the same operation is repeated on the other side of the mould. A certain amount of parting sand which is left sticking to the face of the mould, is brushed off, and if any of the letters have pulled down they are made good. The holes into which the iron guides were driven are also

Fig. 14.

made good, and blacked. Fig. 7 shows the mould at this stage.

The whole face of the mould is next washed over with a thin wash of core gum. This slightly hardens the face, and removes all tool marks. The plates covering the holes in the false joint are now removed, a good wide grip is cut across in a position over the coke bed below, and a bar or rammer end pushed down to the cokes in four or five places. In a corresponding position, three or four holes are cut out of the lower side of the oil-slide core, right to the contained cokes, in order to make a good connection for the air to strike all along the core and escape through the tube shown in the side of the box. This core is now replaced and bolted down through the holes in the grid for that purpose, by means of the hook bolts attached to the bar under the box.

Fish-plates are placed across the bushes, the nuts put on, and the whole screwed tightly together. Particular care is taken that the joint is well finished to prevent any metal getting in and causing a greater lift on that part. The places over the bolts and lifting staples of the grid are now rammed up with sand, vented into the cokes and well sprigged. This precaution is taken because the patches have been known to scab off.

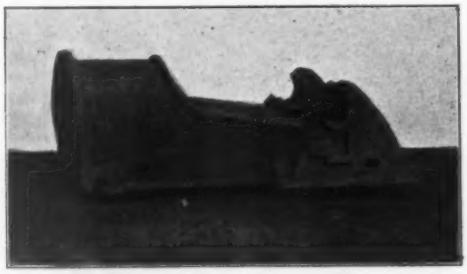


Fig. 15.

These patches are blacked, gum-washed and otherwise finished so that everything is complete and ready for drying. To protect the cylinder body from being burnt by the hot blast as it enters at this end, a piece of sheet iron is laid on rods supported by the core prints. Channel irons, ten inches deep, are placed on the joint of the box, and the top part lowered on to them. It is necessary to pack the top up to allow the hot blast to circulate. The drying is done by means of Shedden's portable furnaces, which are heated with coke. These are shown in Fig. 8. Blast is supplied from a fan to which an electric motor is direct-coupled, the whole apparatus being self contained as shown. The drying is usually done during the night, which gives about twelve hours for this purpose, the sand drying about five inches deep.

At this stage all the cores have been prepared. The writer will not go fully into the details of core-making, but simply illustrates, in Fig. 9, the boxes and grids used. It might, however, be mentioned that the crank-bearing neck cores are made in three parts. This is necessary as, on account of their extension through the facing, they are wider than the main part of the pattern. The small cores are made in oil sand (see Fig. 10).

The next morning the top box is lifted off and lowered on to the stanchions by the side. The mould having been well brushed out and all loose sand and dust removed, the work of coring up then commences. At times it is somewhat difficult to remove the loose sand and dust from the lowest parts, but if a little paraffin is poured in it binds the whole together just the same as water, but without the after effects.

The tubes in the prints at the crank-bearing end through which the hot blast has been blown are filled up with hay or wood-wool bands and sand is firmly rammed in. The round cores which fit in here are cut off at an angle to correspond with the thickness inside. In the facing underneath a double stud is fixed as an extra precaution to hold them in position, and they are held down by the other inside core which fits on them. The next cores fixed are the outside ones in the crank necks, which come into that part of the facing which is left loose on the pattern and drawn in. Three ¾-in. irons are driven through them into the back of the print to hold these in place. Before these cores are fixed a rod is driven down the centre of the print to connect with the coke bed and form a vent for the centre part of the three cores. A small groove is cut round the face of the print. This is filled up with soft loam, which stops any metal getting to the vents when the core is down in its place, and also shows that the core has been right down. A double stud is nailed on the mould, of the thickness required under this core, and the core is lowered into its place. After being fixed it is lifted out and examined to see whether it has touched the soft loam all round and been right down. When this has been proved the core is replaced. Both necks having been cored up, the spaces round are filled with pieces of waste or paper to prevent anything dropping down, as this end is now practically finished.

Fig. 11 shows more clearly the down runners, ingates, and the outlet for the vent from the cylinder core. The core for the cylinder body is now lowered into its prints, and abuts the oil-slide core. After this is fixed the same precautions are taken to prevent anything dropping into the spaces. A hook bolt is passed through the print end to the bar mentioned when preparing for bedding the pattern in, and this end is firmly bolted down. The spaces over the bolt hole and lifting staple are made good, as described in the case of the oil-slide core. As these cores abut and are a continuation of each other, any variation at the point of contact is made good, the joint and all patches being blacked and well dried. For this purpose small petrol blow-lamps are used which are very powerful. Fig. 12 shows the mould at this stage.

The back core is now fixed in position. This core, as previously explained, covers the in-gates and forms one side of the down runners. It also forms the top half of the cylinder-end flange, makes up the draw print and holds down the cylinder body core at that end. The vent from the cylinder core is now connected to the box end and the space left for drying rammed up.

The six round cores for foundation bolts are next fixed to complete the coring. Pieces of clay are placed on the cylinder core, the oil slide core and the centre parts of the crank-bearing cores to try the space left for metal when the top box is replaced. This is now done, the weight being lowered off, after which the top part is again hoisted and the thickness of clays measured to ensure the correct thickness of metal. The exact amount of space having been now found between the crank-neck core and the top part of the mould, studs of the required thickness are placed on these cores so that when the top is finally lowered they cannot lift. After all clays have been removed and a little whitening put on the top of the studs and on all the cores which touch the top part, the top is again lowered to make sure that all parts which should touch do so, and that there has been no crushing. The top part is again hoisted, and if everything has been found satisfactory the waste or paper, etc., which has been in the spaces is removed. As a rule a considerable amount of dust has collected on this, so before it is disturbed paraffin is sprinkled over it to prevent it dropping into the bottom of the mould.

Everything is now ready for closing, and the top is lowered into position. Along the joint there are some places where the two parts of the box do not touch, so wrought-iron wedges are driven into these places. Thus iron meets iron all along, and prevents any crushing when the bolts are screwed up. Iron packings are placed on the box to support the top binders. These binders are placed in position, hook bolts are attached to the links from the bottom binders and brought into the slots as shown on the slide. The whole is then screwed tightly down (Fig. 13); runner box and risers are made up, runner pegs withdrawn, and pieces of tin placed over the down runners. These are used instead of plugs to get the runner box full of metal, the time taken to melt the tin being sufficient for this purpose. Care is taken to see that all the vents are clear, and the joint of the box stopped at the back of the runners and the places where the mould comes close to the edge of the box.

All is now ready for the metal being poured in. Fig. 14 represents the actual operation in progress. As soon as practicable the heads are knocked off the runners and risers and cleared away, the bolts loosened, and binders removed. All the nuts on the bolts used for the lifting grids are screwed off, and packings, fishplates, etc., collected and stored away. The top part is lifted off, which leaves everything free for contraction. The casting is left in the sand all the next day and taken out the following morning. In doing this the box part is first removed, thus leaving all the bars which have been used for bolting down purposes free, as these were all packed under the middle part of the box. The casting can now be lifted clear and taken to the fettling shop. Fig. 15 shows the finished casting.

In conclusion I should like to thank Mr. Campbell for his kindness in allowing me the services of the works photographer and for all the other facilities with which I have been favoured in the preparation of this paper.

False Economy in Patterns.

Discussing the relations between foundry and machine-shop, in a paper recently presented before the Superintendents' and Foremen's Club, Oakley, Cincinnati, U.S.A., H. M. Ramp contended that the machine shop tries to save too much on the cost of patterns.

"The average patterns in the average foundry to-day are not made as good as they were ten years ago. The average customer cannot afford to spend money for good patterns to produce good castings, but he can afford to spend money for improved machinery in the machine shop to better the quality and cheapen the cost of the finished product. Too often he holds the initial cost of the pattern so close to his eye that it obscures the entire horizon of his vision.

"The machine shop makes templates and gauges of iron and steel, with careful and elaborate provision for their care and protection. To the foundry is furnished a pattern of wood, often lightly constructed, sometimes of green timber, and after it has been hauled from shop to shop for eight or ten years, it is stored in old sheds, or back of sand heaps. The foundryman is hauled over the carpet and arraigned, first, because the castings are not true, and, second, because the pattern has been abused. Is it any wonder that castings come out of shape at times? Many machine concerns have inspectors who check up every piece of work done in the factory. Some have inspectors who check up every gauge and template at stated periods to discover error and prevent mistakes; but seldom does a concern check up its patterns periodically to know that they are true. Usually it will be done after having to reject a batch of castings, and only then is the pattern found to be at fault.

"There is one reason greater than all others why foundries should have much better patterns than formerly. The trend of the times is to reduce the skill demanded in the individual and put more dependence in the improved machinery of to-day. This is as true in the foundry as elsewhere. We do not make the moulders we did 20 years ago, and the patterns that the foundries get are their improved machinery or the old-fashioned tool as the case may be, and are the positive foundation for their product.

"But the pattern-maker and his patterns are not the only thorn in the flesh that the foundry possesses; there is another and greater than he—one whose commands carry more grief and pain. It has been aptly said 'that the pen is mightier than the sword,' for where, oh, where, would you find the sword with which to make the foundryman do what he does in obedience to the pen in the hands of the designer?

"I have seen many castings designed that were perfectly fitted for the purpose for which they were made, but were so designed that the moulder could not make a perfect casting, for the excessive strains due to unequal proportions made the castings crack or warp, or required special treatment that kept the foundryman in hot water from the time the job came into the shop until it was out. It is easy enough to say we do not need any more metal at this or that point; it is very creditable to be able to design a machine with the maximum utility and the minimum weight, but there are certain fixed, unalterable laws in the shrinkage or contraction of cast iron that are not studied as closely by the designer, or at least considered, as they should be.

"I have seen many castings command a higher price simply because they were designed with a view to saving metal, where, as a matter of fact, the saving in metal was more than lost in increased price. The foundry gets very little opportunity to protest against designs that are difficult to mould, and seldom is it consulted. The machine shop may protest and get changes because of high machining cost, but rarely does the foundry get concessions because of high moulding cost. If the foundry were consulted more by the designer both would be benefited to no small degree. It may seem incomprehensible that any good could come out of the foundry, but the practical man in the foundry can pass better judgment on the freaks and fantasies of cast iron than the finest designer in the land, and it is to the loss of both if they do not swap stories and criticisms over every new design."

Molybdenum in Steel.

The Primos Chemical Company, of Primos, Pennsylvania, writes as follows in response to an inquiry regarding the use of molybdenum in steel:—"There is a little more demand for molybdenum now than there has been for the last seven years. From 1900 to 1905 the consumption was at its greatest, our firm alone producing upward of 50 tons of metallic molybdenum per year. Consumption then dropped to a few tons per year, but is now gradually coming up again to an average of two tons per month in the United States. Both molybdenum and ferro-molybdenum are now used little in molybdenum tool steels, but are used in connection with tungsten in most of the high-class tool steels; also in connection with vanadium. In certain steel castings and other railroad work, molybdenum is also used up to 1 per cent. Some of the European armour plates contain up to 2 per cent. of molybdenum."

The Production of Small Ingots in Quantity.*

The question whether small ingots or blooms form the most suitable material for rolling in small works, especially those producing medium and small bars, is a frequent subject of argument. Many works cast only large ingots, and rough these down to blooms for the smaller mills; but there are quite as many works in which small ingots are cast, particularly for the wire mills; these ingots being small enough to roll down in a couple of heats. In view of the superfluous and therefore useless labour involved in making ½ to ¼ in. rods from 2- to 4-ton ingots, it seems that the principle of starting with small ingots in the first place is perfectly justified; and this will explain the fact that several new works have been equipped for turning out ingots weighing 2 to 4 cwts. It is true that the ordinary method employed for casting small ingots is comparatively expensive, and is unsuitable for production in quantity; but these drawbacks are claimed to be obviated by the author's system, described and illustrated below, which enables small

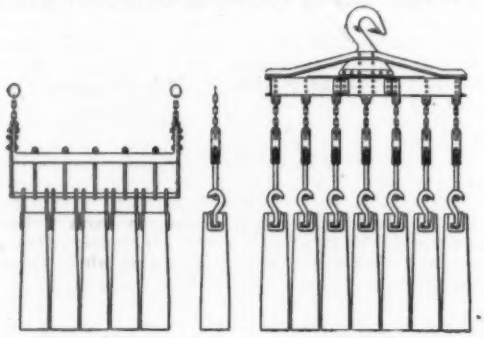


FIG. 1.

FIG. 2.

ingots to be produced cheaply in large quantities, in a small space, and without exposing the workpeople to radiant heat.

As in the existing system, the ingots and moulds are arranged in batteries for pouring; but the method of handling the moulds is different. To strip the moulds the usual practice is to attach each of the crane hooks to a mould by hand; and as not more than two men can work at a crane without getting into each other's way, the number of moulds raised at each lift is never more than four. By the time the crane is ready to take another set, the men are exposed to the heat of the ingots already drawn; and this heat becomes more and more inconvenient as the work proceeds. Several methods have been already adopted to remedy this inconvenience by drawing several moulds at a time, and, as far as possible, by mechanical means alone; but none of them proved successful. The drawbacks in question have now been removed by the method employed at the Bismarckhütte Works, and in two Hungarian ironworks. In this method the whole battery of ingot moulds is stripped at once by means of a hanger, the members of which engage automatically with the moulds and disengage therefrom after the operation, without any manual labour being required, so that one man can superintend the whole operation, his work, moreover, being confined to manœuvring the crane.

* G. Marton in "Stahl und Eisen."

The fundamental feature of the whole device is constituted by a cast-steel eye (Fig. 1) attached to dovetailed recesses in the lateral surfaces of the ingot moulds and secured by wedging. The arrangement of the hanger is illustrated in Fig. 2, by means of which the moulds can be raised simultaneously, in rows of five to seven, and carried away to cool. The same figure shows how a number of these hangers are combined in one frame, so as to strip a whole battery of moulds at one operation without manual labour. The hangers may also be used for arranging the moulds on the casting plate. The number of moulds going to form a battery depends on the dimensions of the ingots, 49 moulds measuring 8 in. square at the base, being arranged in seven rows, whilst 63 moulds 5½ in. square will form a nine-row battery of seven moulds in each row. Fig. 3 shows a whole battery of moulds being drawn from the ingots by means of the above device.

The hydraulic stripper can be dispensed with by adopting the practice in vogue at the Krompach Works (Fig. 4), where the moulds are stripped in rows, the crane crab being run forward as each row is being handled, so as to tilt the moulds and thus detach the ingots, which then slip out as the moulds are drawn up by the crane. The stripped ingots may be left to cool on the plate, and afterwards loaded into trucks by means of the crane or other appliance. It is, however, desirable to transfer the ingots to the rolling mills whilst still hot, in order to prevent needless waste of heat, since the small ingots will keep red-hot for hours when left undisturbed in groups. The simplest way to transfer them is by providing the casting plate with sides and hooks, as

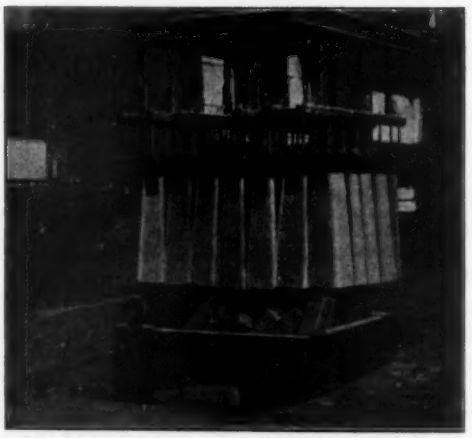


FIG. 3.—BATTERY OF INGOT MOULDS AFTER WITHDRAWAL.

shown in Fig. 3, so that the whole can be lifted at once by the crane, and the ingots discharged into tip trucks, which will deliver them to the cold pits at the mills; or else the plate can be mounted on a truck and run to the mills, the ingots being then tipped into the pit. When this plan is followed, another plate can be got ready in the casting pit in the meantime, and a fresh battery of moulds poured, so that the work goes on continuously and an increased output is obtained. This arrangement, as

carried out at the Resicza Works, is illustrated in Fig. 5.

The advantages of the new system may be summarised as follows:—The output can be doubled with the same appliances and casting pit, in less than half the space usually required. The work can be done with a smaller number of hands, being mostly mechanical, and the men are protected from the heat of the ingots. Order is easily maintained, the ingots remaining grouped in batteries. The life of the casting plates is lengthened, since the hot ingots are removed almost immediately. There is no risk of serious damage to the ingots from overflowing steel, the ingot moulds being so close together that any such steel cools quickly and the moulds can be detached from the crust without injury. The ingots can be taken to the mill whilst still hot, thus increasing the productivity of the mill and reducing the fuel consumption and waste of metal. Finally, the method can be adopted in works which, though needing such small ingots, have not hitherto been able to make them conveniently and economically.

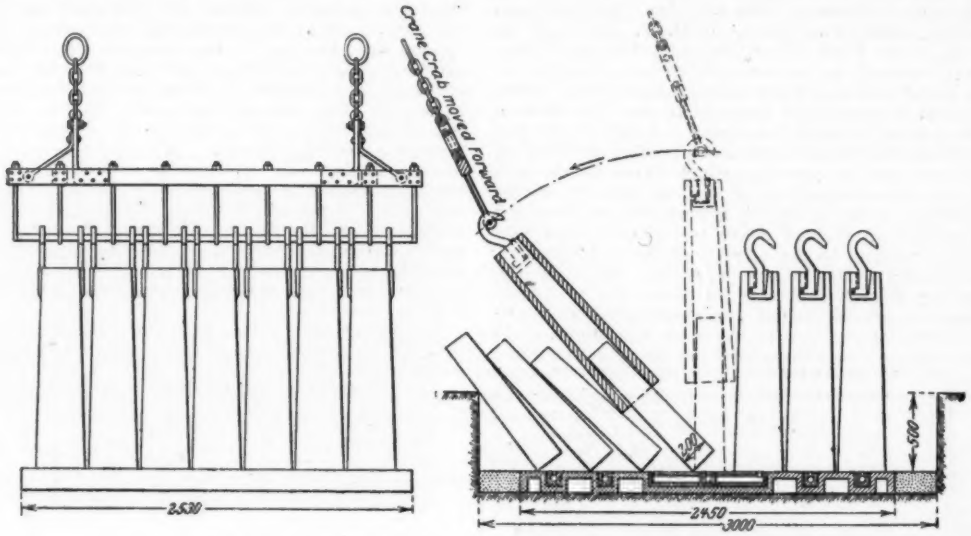


FIG. 4.—METHOD OF INGOT STRIPPING ADOPTED AT THE KROMPACH WORKS.

(*Dimensions in Millimetres.*)

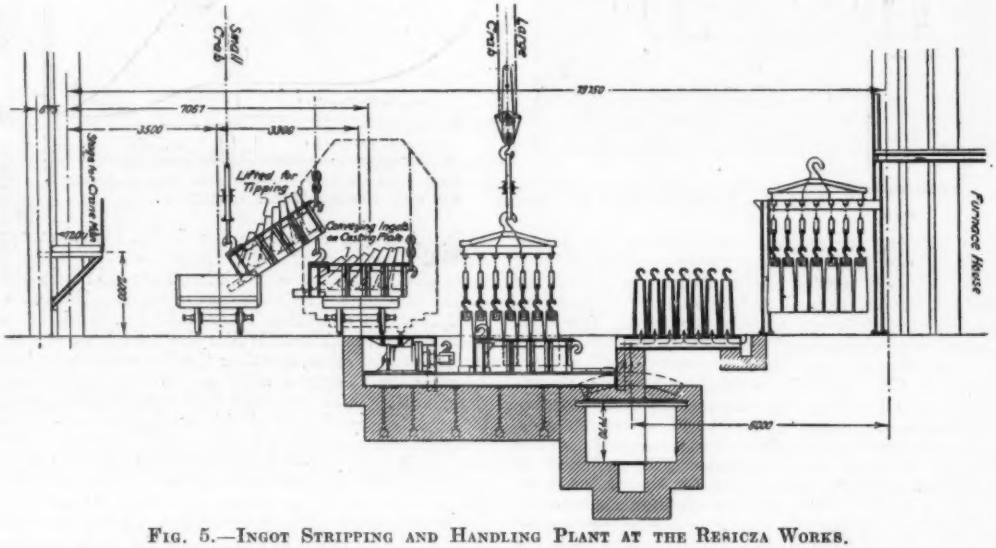


FIG. 5.—INGOT STRIPPING AND HANDLING PLANT AT THE RESICZA WORKS.

(*Dimensions in Millimetres.*)

THE MAPLES FOUNDRY COMPANY, of Nottingham, have removed to the Phœnix Works, West Bromwich.

Foundry of an American Motor-Car Factory.

In a recent issue of "The Iron Age" there appears an interesting description, by O. J. Abell, of the works of the Ford Motor Company, Detroit, U.S.A. This company, as is now well known, specialise in one model of car at a low price, and the whole establishment is accordingly designed to meet the demand for the greatest possible economy and rapidity of production. The works have so far reached a record of 500 cars built in one day, which figure speaks well for the organisation, since the development of the works has occupied less than nine years. From the description mentioned above we extract some particulars relating to the foundry of the establishment, the general outlay of which will be seen from the drawing, Fig. 1. It may be noted that the rapid expansion of the output has necessitated manufacturing under continually changing conditions. At the present time a new machine shop, a new four-storey building for general manufacture and assembly, more than doubled power facilities and additions of 200 ft. each to the heat-treatment and foundry buildings are in process of erection or completion. Other new buildings are already projected. The location and arrangement of the various manufacturing buildings have taken their present form in part because of the necessities arising out of an expansion so rapid that new buildings were outgrown before they were occupied. The building construction in general is of reinforced concrete skeleton for the four-storey sections, and steel supporting columns on the machine-shop floors, carrying saw-tooth roofs at one storey height. The foundry and heat treatment buildings, as well as the power and heating plants, are steel frame structures, and are isolated units in the building plan, but the remainder of the buildings are continuous, covering an area approximately 860 ft. long and 820 ft. deep.

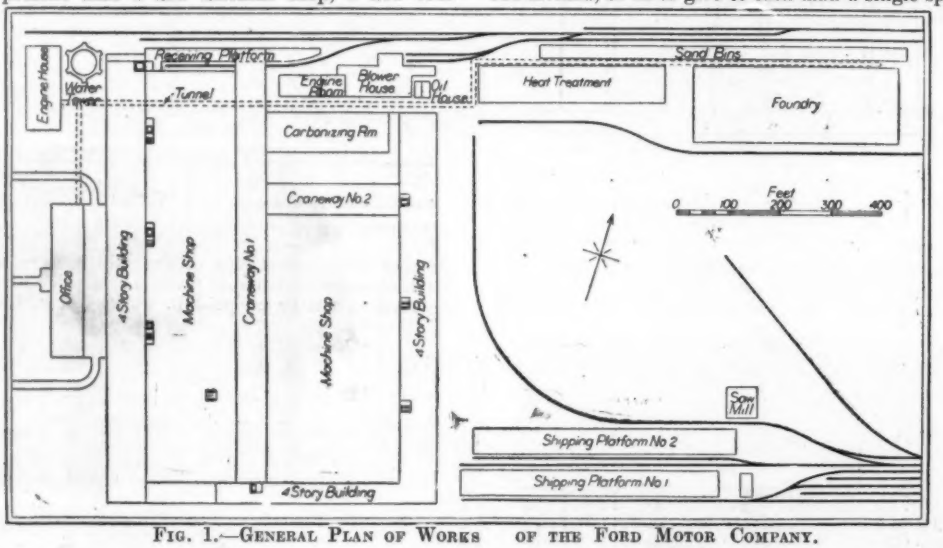


FIG. 1.—GENERAL PLAN OF WORKS OF THE FORD MOTOR COMPANY.

The Foundry.

The present foundry building is 201 ft. long by 148 ft. wide, but is being extended to a length of 401 ft. The building is of steel framework, with a saw-tooth roof, and includes, in addition to the foundry floor, a large core room and sand-mixing room on one side, and on the opposite side the chipping, grinding and rumbler department for the cleaning of castings. The foundry moulding and pouring floor is between. The melting equipment consists of two No. 60 Newton cupolas, built by the Northern Engineering Works, Detroit. All of the moulds are machine-made, the equipment consisting of 29 machines, including squeezers of the Berkshire Manufacturing Company's type, Pridmore roll-out machines, and the Killing Moulding Machine Company's roll-over machines. For the greater part these machines are arranged around the wall, preserving the major portion of the floor space as a pouring floor.

The operations involved in making the moulds are sub-divided, so as to give to each man a single specific task. A helper cleans up the flasks, one man operates the machine, another helper carries over the cope and drag to the moulding floor and lays them down, another man blacks up the mould, still another performs the operation of skin-drying, and in the more complicated moulds like the cylinders, one man sets the small cores, another the large cores, and still another the chaplets, while a last operator locks up the mould. It is apparent that common labour may be used for nearly all of this work.

As evidence of the effect of this system on production, it is recorded that on this floor space of 12,000 sq. ft., 7,000 castings were made in one day, or at the rate of 18 to the man, including labour of all kinds connected with the foundry. With the extension of the foundry building and the installation of the overhead trolley equipment a continuous pouring system will be placed in operation. The accompanying illustrations, Figs. 2 and 3, show the general interior arrangement of the foundry and the manner of piling the moulds for pouring. An ordinary day's output includes the making of 74 cylinder flasks, 700 brake-shoe flasks, 150 piston-ring moulds, each mould containing four pots 7 in. long; 350 piston

moulds, each containing four pistons; 200 cylinder-head moulds, and other parts in proportionate numbers. This rate of production, unusual as it may seem, falls considerably behind the production rate in other departments of the plant.

The sand-mixing room is immediately at the rear of the cupolas, and is so arranged that sand may be brought from the bins by the gantry crane and discharged directly into elevator hoppers located above the sand mixers. These sand mixers are placed on a mezzanine floor at sufficient height so that steel sand buggies may be placed below. The mixed sand then drops by gravity into these buggies, to be hauled

FIG. 2. GENERAL VIEW OF FOUNDRY POURING FLOOR.

either to the moulding machines or the core room. Pneumatic shakers for riddling the sand are bracketed on the wall, with sufficient space between so that the sand buggies can be backed in to be filled.

As regards the core room, the general arrangement is shown in Fig. 4. The core-makers' benches are arranged along the sides at right angles to the walls, and each operator makes but one core continuously. Steel core moulds are used, and in this respect, as in every other department, particular effort is directed towards the making of accurate castings.

FIG. 3.—FLOOR ON WHICH CYLINDER MOULDS ARE MOUNTED AND POURED.

It is the intention to use such methods, moulds, jigs and gauges throughout in the making and finishing of all parts, that variations in the car parts as they come to the assembling floor will be absolutely eliminated, and the assembling operations will at no time involve fitting work. At one end of the core-room are six Byram & Company core ovens for small cores. These ovens are fronted by a steel rack. The cores are placed on this rack for inspection and patching. Two men handle this work exclusively. Four other men handle the cores in and out of the ovens. At the opposite end of the room are four car ovens. A transfer rack traverses the oven front, and the core-car tracks extend across the core-room floor, providing for the handling of the larger cores.

The Use of Coke-Oven Gas.

Mr. E. H. Scott, head chemist at the Salford Gas Works, contributed an interesting Paper on "The Carbonisation of Coal in Bulk" to the proceedings at a recent meeting of the Scottish Junior Gas Association. He pointed out that the modern by-product recovery coke oven, although primarily developed and designed for the production of coke, could be, and was, utilised for the production of gas, and many towns in Germany and America were now being supplied solely with coke-oven gas. There were some few districts in England where coke-oven gas was supplied to the public for lighting, etc., either through a gasworks or through their own mains, but the utilisation of coke-oven gas had not made very much progress in this country, probably owing to the uncertainty of the supply. The modern

FIG. 4.—SHOWING GENERAL ARRANGEMENT OF CORE-ROOM.

regenerator coke oven had a surplus of something like 50 per cent. of the gas made. Supposing a coal yielding 10,000 cubic feet of gas per ton were being carbonised, 5,000 cubic feet of gas per ton would be used to heat the ovens, and the remaining 5,000 cubic feet would be available for other purposes. What was the coke-oven proprietor to do with this surplus? There were three ways open to him, all of which were utilised. (1) He could burn it under his boilers to produce steam (*i.e.*, if he needed power outside the coke-oven plant). This was a very crude way, and the value per thousand cubic feet, compared with slack on a calorific basis, was only about 1½d. (2) He could purify the gas and use it in gas engines for the production of electric power, which was then distributed. This had been done largely in the North of England, where an electric supply syndicate was utilising the waste heat from many manufacturing processes. (3) The purification of the gas and distribution for heating and lighting, etc. It was already partly purified, as the ammonia and tar, and also benzol, were recovered. The H_2S only had to be removed, and then the gas was ready for distribution. In Germany, coke-oven gas was becoming a serious competitor with the gasworks, and it was being distributed, through high-pressure mains, to towns and villages some considerable distances from the works.

The Annealing of Steel Castings.

Dr. Oberhoffer, of the Breslau Technical Schools recently delivered a lecture before the Düsseldorf foundrymen on the annealing of steel castings. Although the subject is of great practical importance, very little of an instructive kind has found its way into either periodicals or text-books.

Starting from an illustrated description of the characteristic structure of mild-steel castings, he traces a resemblance, which is already well known, to meteorites on the one hand and forged or rolled steel in the overheated state on the other. The structure of steel castings is greatly influenced by the casting temperature, rate of freezing, and rate of cooling after solidification, but of these matters very little is known beyond a few general statements.

The main point in the author's contention was that the most marked improvement in mechanical properties is brought about by annealing at a temperature just beyond Ac3. With two well-chosen examples he shows by means of microphotographs, etc., that both the crystalline structure and resistance to dynamic stresses are in complete accord with the teaching of the iron-carbon equilibrium diagram when modified as required by the presence of the usual amounts of silicon and manganese existing in steel castings.

Dr. Oberhoffer obtained bars of steel measuring 45 × 45 × 410 mm., and annealed these for six hours at various temperatures under otherwise constant conditions. Test-pieces were then prepared (presumably of the German standard size), and the following series of results were obtained :—

Annealing temperature.	Yield point.	Maximum stress.	Elongation.	Reduction of area.	Impact.
	Tons per sq. in.	Tons per sq. in.	Per cent.	Per cent.	Kgm. per sq. cm.
Unannealed.	11.5	26.22	25.9	30.0	3.64
770°C	9.59	25.64	27.9	51.3	2.30
800°C	11.18	26.02	28.2	53.5	2.09
830°C	10.73	25.80	27.8	53.5	1.85
860°C	11.58	26.80	28.5	56.7	1.45
890°C	15.18	26.74	28.7	58.8	13.50
920°C	16.67	27.71	29.9	59.2	17.16
950°C	16.52	26.61	29.8	55.2	16.24
1,000°C	16.63	26.66	30.5	55.2	10.33

The steel contained C. 0.11, Si. 0.40, Mn. 0.60, S. 0.035, P. 0.030.

The obvious comment on these results is that the maximum stress and elongation per cent., which form the basis of acceptance for nearly all commercial castings, are not very greatly improved by the annealing operation. This observation, though not perhaps generally true, has been made many times before, particularly in relation to very mild steel castings; and the fact lends a certain amount of colour to the claim that steel castings which do not require to be annealed can be produced by certain processes. So long as the quality of such castings is measured by the maximum stress and elongation per cent., and in no other way, the statement wears a semblance of truth, the only contentious point being that some particular process or mode of melting the steel is required to produce that result. As a matter of fact, the same kind of result may be attained frequently, if not invariably, whether the steel is melted in the crucible on the open hearth, in the electric furnace or by the Bessemer process.

The most remarkable distinction, as pointed out by Dr. Oberhoffer and previously recorded in the FOUNDRY TRADE JOURNAL (April, 1912, page 213), is the comparatively great resistance to shock stress exhibited by material which has been annealed at temperatures sufficiently high to break down the castings structure, or, in other words, to a temperature somewhat beyond Ac3.

It may safely be predicted that some such form of shock tests as the one used by Dr. Oberhoffer, and in use already in some British works as a source of private information, will ultimately occupy an important place in industrial specifications. The impact test piece is not more difficult to prepare than an ordinary bender, and the results are much more instructive.

The impact test if applied intelligently to steel

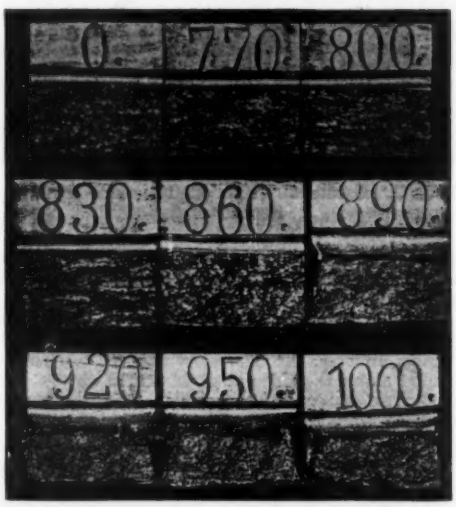


FIG. 1.—FRACTURES OF IMPACT TEST PIECES.

castings will do something to lessen the delay and difficulty arising from defective test-pieces. It is well-known to every capable technologist that during freezing, the shrinkage of a mass of metal continues after the metal has become too viscid to flow from any upper layer into the shrinkage cavities. This unavoidable circumstance, quite apart from the possible presence of occluded slag or gas cavities, makes it imperative that from time to time a test-piece should contain one or other minute defect. Although such slight cavities or enclosures are generally insignificant in their influence on the casting as a whole, they are fatal to the test-piece if they happen to lie somewhere along the length of its parallel sides and near the surface. Whether they lie near the centre or on the surface they lessen the contraction of area of the test-piece. If they lie near or on the surface they decrease the elongation and sometimes cause rupture before the normal maximum stress is reached.

The longer the test-piece the greater the danger that it may break prematurely owing to the presence between the datum points of one or other of these minute and unavoidable defects. Indeed, one of the best means of detecting slag occlusion or slight sponginess in forged or rolled material is to cut

a transverse test-piece of rectangular section, as long as possible, and carefully observe its behaviour under tensile stress.

It follows from these considerations that any form of test would be useful which will supersede or supplement the ordinary form of tensile, and be slightly or not at all upset by defects of small practical moment. The impact test answers the requirement, as the material is stressed immediately about the notch only; and from a bar 6 in. long three or four tests could be made. This is not the place, and perhaps the time is not yet ripe, for the adoption of some form of notched bar impact test, but there is certainly room in industrial specifications for a test which covers the deficiencies of the present tensile and bender, within their own range, and supplies information of special value quite outside their scope.

The appearance of the fractures of the impact test-pieces referred to in the table herewith, are reproduced from "Stahl and Eisen" in the accompanying illustration, Fig. 1.

The marked improvement in the appearance of the test-piece which had been annealed at 890 deg. C in comparison with the fracture of those annealed at

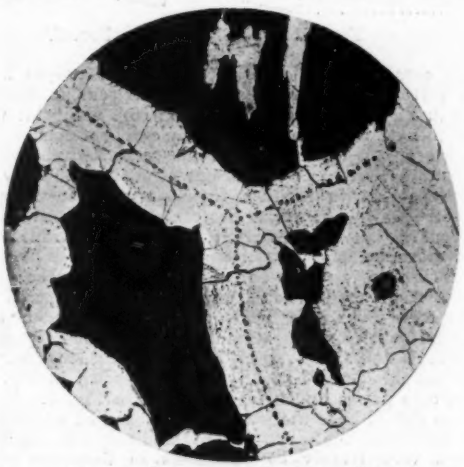


FIG. 2.—BROKEN MANGANESE-SULPHIDE ENVELOPES IN STEEL CRYSTALLISATION.

lower temperatures is a striking confirmation of the impact figures. Dr. Oberhoffer concluded his discourse with reference to the influence exerted by non-metallic enclosures, notably sulphide of manganese, on the structure and mechanical properties of steel castings. He thinks that manganese sulphide existing as globules is of very little consequence; and so far as the mass of the casting itself is concerned his conclusion is confirmed by general experience. It is only when these globules happen to lie on a stressed surface such as the parallel length of a test-piece that they become seriously objectionable. But not every foundryman will agree that "The influence of small masses of sulphide of manganese is rather favourable than otherwise as they prevent suffusion."

When sulphide of manganese or other brittle non-metallic impurity forms complete envelopes separating the crystals from their neighbours they are most harmful. No kind of heat treatment to which a casting could be submitted is able to remove such envelopes, and though the ultimate microstructure may be improved, the line of fracture under stress follows the brittle envelope. The envelopes may be broken or continuous—one of the former is shown in Fig. 2. The effect of either kind of envelope is the same, viz., abnormal and inevitable brittleness.

Specifications for Brass and Bronze Alloys.

The following mixtures are advocated in the United States Government specifications issued by the Bureau of Steam Engineering. The composition must be made of such materials as will give the required chemical analysis. Scrap will not be used except such as may result from the process of manufacture of articles of similar composition.

Commercial Brass.—Copper, 64-68 per cent.; zinc, 32-34 per cent.; iron, 2 per cent. (maximum); lead, 3 per cent. (maximum).

Muntz Metal.—Copper, 59-62 per cent.; zinc, 39-41 per cent.; lead, 0.6 per cent. (maximum).

Brazing Metal.—Copper, 84-86 per cent.; zinc, 14-16 per cent.; iron, 0.06 per cent. (maximum); lead, 0.3 per cent. (maximum).

Gun Bronze.—Copper, 87-89 per cent.; tin, 9-11 per cent.; zinc, 1-3 per cent.; iron, 0.06 per cent. (maximum); lead, 0.2 per cent. (maximum).

Journal Bronze.—Copper, 82-84 per cent.; tin, 12½-14½ per cent.; zinc, 2½-4½ per cent.; iron, 0.06 per cent. (maximum); lead, 1 per cent. (maximum).

Valve Bronze.—Copper, 87 per cent.; tin, 7 per cent.; zinc, 6 per cent.; iron, 0.06 per cent. (maximum); lead, 1 per cent. (maximum).

Manganese Bronze.—Copper, 57-60 per cent.; zinc, 37-40 per cent.; tin, 0.75 per cent.; iron, 1 per cent. (maximum); aluminum, 0.5 per cent. (maximum); manganese, 0.3 per cent. (maximum).

Monel Metal Castings.—Nickel, 60 per cent. (minimum); copper, 33 per cent.; iron, 6½ per cent.; aluminum, ½ per cent.

Cast Naval Brass.—Copper, 59-63 per cent.; zinc, 35½-40½ per cent.; tin, ½-1½ per cent.; iron, 0.06 per cent. (maximum); lead, 0.6 per cent. (maximum).

Phosphor Bronze.—Copper, 80-90 per cent.; tin, 6-8 per cent.; zinc, 2-14 per cent.; phosphorus, 0.30 per cent.; iron, 0.06 per cent. (maximum); lead, 0.2 per cent. (maximum).

Screw Tube Fittings of Brass.—Copper, 77-80 per cent.; zinc, 13-19 per cent.; tin, 4 per cent.; iron, 0.10 per cent. (maximum); lead, 3 per cent. (maximum).

Metallic Nickel.—Nickel, 97 per cent. (minimum).

Thrust Rings.—Copper, 82-84 per cent.; tin, 12½-14½ per cent.; lead, 2½-4½ per cent.

Monel Metal Ingots.—Nickel, 60 per cent. (minimum); copper, 38 per cent.; manganese, 2 per cent.

Small amounts of other ingredients not injurious to casting qualities, or detrimental to strength or non-corrosive properties are allowed.

Cupola Capacities.

IN a Paper recently presented before the Pittsburg Foundrymen's Association, David McLain included the following, regarding cupola capacities:—Any cupola may be arranged to melt 10 lb. per hour per square inch of cupola area, when just the proper amount of coke is used. The following table may prove of interest:—

A 30-in. cupola should melt	3½ tons per hour.
A 36-in. cupola should melt	5 tons per hour.
A 42-in. cupola should melt	6½ tons per hour.
A 48-in. cupola should melt	9 tons per hour.
A 54-in. cupola should melt	11 tons per hour.
A 60-in. cupola should melt	14 tons per hour.
A 66-in. cupola should melt	17 tons per hour.
A 72-in. cupola should melt	18 to 20 tons per hour.

Cupolas can be found melting faster than this, but it is a mistake to melt faster than quoted, unless on very long heats. Generally, melting conditions are favourable when melting steel, but not so with iron melted in the cupola.

Core Prints on Patterns.

By Walter J. May.

When foundry patterns are made by a man who has had close experience with actual foundry work, and who knows how the patterns will probably be placed in the moulds as regards the position of the cores during the pouring in of the molten metal, there is not often much fault to be found with the core-prints or their corresponding core-boxes; but when pattern-makers are not well up in actual moulding details, and are possibly making patterns from drawings made by draughtsmen equally

FIG. 1.

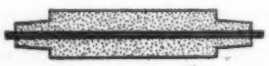


FIG. 2.

ignorant of foundry practice, but who insist on putting in every detail on their drawings, then trouble often arises to the moulders. Of course, at times one gets hold of patterns made by carpenters and others who are quite ignorant of what is really needed on a pattern, it being not an infrequent occurrence to have the patterns exact replicas of what the finished casting is to be, holes being left where cores come, and the like, but as such patterns have in any case to be altered, and in many cases core-boxes have to be made for them, they do not cause serious trouble, as naturally the foundryman has the work done in the way which favours him most—or at any rate he should do.

With upright cores the prints do not require to be so long as with horizontal ones, as there is little upward strain, but squarely-cut prints cause the moulder a lot of trouble, as he cannot see the fit at either top or bottom. Take, as an instance, a core such as that shown in Fig. 1., when it has to stand vertically in the mould. If made with tapered prints as shown in the shaded portion, it drops into position quite readily, but if the prints are square in section, as shown by the blacked-in portions, the

FIG. 3.

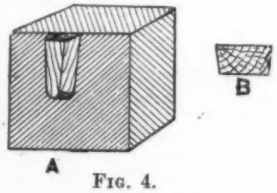


FIG. 4.

moulder has considerable trouble to get them into the holes in the mould made for their reception.

With a horizontal core as shown in Fig. 2, a less amount of taper would be necessary, but owing to the upward pressure of the molten metal the print should be a long one as shown, and whether the core is made in a box or struck up against a templet or "striking board" with an iron barrel through the centre of the core, the print ends should be the same in regard to length and taper. A square-ended core as shown by the black portion in Fig. 1 is apt to drag more or less, and not sit properly at the bottom of the space left for its reception, and for this reason the taper on the core should be slightly greater than that of the print affixed to the pattern, but still only enough to permit of the core passing freely to its seating.

The prints will be round or square as a rule, according to the shape of the core, but the same general form will hold good whatever the shape may be. The round print on a pattern in cases where

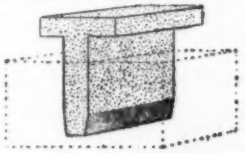


FIG. 5.

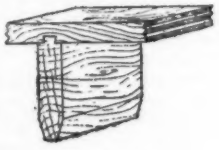


FIG. 6.

the core can be placed directly in position—as with a vertical core for instance—will appear in section as in Fig. 3, but for a horizontal core the print will be put on as in Fig. 4 at A, a cross section of the print appearing as at B in the same figure. These prints should be of a different colour to the body of the pattern to indicate their purpose, bosses and other projections on a pattern being of the same colour as the pattern itself, whether they are fixed or movable.

Prints for cores to be held on the bottom or sides of a mould only, should only be slightly tapered as the cores have to be held by the part bedded in the mould plus (as a general rule) a few nails passed through them; but the part of the core bedded in the mould should be fairly deep, as shown in Fig. 5, the core prints appearing as shown in Fig. 6. Such cores should have the lower edges sloped off as shown, to facilitate the work of the moulder, who has to work very largely by judgment in inserting such cores, as their form and size prevents him seeing very clearly.

Where partially enclosed cores have to be dealt with, as in the case of air chambers, as shown in Fig. 7, the end in the walls of the mould should be as long as possible within reason, for although nails

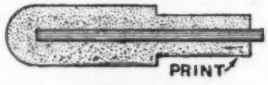


FIG. 7.

or chaplets are used as additional supports, the firm holding of the end of the core is of considerable benefit. Generally speaking the core itself should have, as a guide to the moulder, a shoulder as shown, but this need not be more than half an inch deep, while in many cases it can be done without if moulders work carefully. The core must fit the impression left for its reception in the mould, for if the core end is too small the whole thing will rise with the pressure of the metal. In every case the core prints should be so arranged as to facilitate the work of the moulder, and this not particularly to make things easy for him, but principally to ensure the turning out of the casting as accurately as possible. From a general point of view the

better the pattern is from the moulder's point of view, the better will be the casting so far as shape and size is concerned, while this alone tends to considerable economy in both machine and fitting shops, a well-shaped casting being far less trouble to deal with than one which is mis-shapen.

Standard Specification for Refractory Material.

At the recent meeting of the Institute of Gas Engineers, the Refractory Materials Committee presented their annual report, which includes a standard specification for silica bricks, blocks, tiles, etc., which has been drawn up by the Committee in collaboration with representatives of the Retort and Firebrick Section of the Society of British Gas Industries, together with several other leading makers of this class of material.

The following is a copy of the specification referred to :—

Standard Specification for Refractory Materials.

SECTION 3.—SILICA BRICKS, BLOCKS, TILES, ETC.

The material covered by this specification is divided into two classes :—

(1) That containing 92 per cent. and upwards of silica, and hereinafter called "silica" material.

(2) That containing from 80 to 92 per cent. of silica, and hereinafter called "siliceous."

REFRACTORINESS.

1. Test pieces of the material shall show no sign of fusion when heated to the following temperatures :—

"Silica" material—not less than Seger cone 32 (about 1,710 deg. C.).

"Siliceous" material—not less than Seger cone 29 (about 1,650 deg. C.).

The test shall be carried out in an oxidising atmosphere; the temperature of the furnace being increased at the rate of about 50 deg. C. per five minutes.

CHEMICAL ANALYSIS.

2. A complete chemical analysis of the material is to be provided when required by the engineer (or purchaser) for his personal information only.

SURFACES AND TEXTURE.

3. The material should be evenly burned throughout and the texture regular, with no holes or flaws. All surfaces shall be reasonably true and free from flaws or winding.

CONTRACTION AND EXPANSION.

4. A test piece, when heated in a gas muffle or electric furnace to a temperature of Seger cone 12 for two hours shall not show, on cooling, more than 0.75 per cent. linear contraction or expansion. The temperature of the furnace shall be maintained constant throughout the testing period; and the test piece shall be at least 4½ in. long by 4½ in. wide—the ends being ground flat, and the contraction or expansion measured by means of Vernier callipers reading to 0.1 mm.—a suitable mark being made on the test piece, so that the callipers may be placed in the same position before and after firing. The test samples shall not be taken out of the middle of a brick, block, or tile, but shall be representative of the whole.

VARIATIONS FROM MEASUREMENTS.

5. In the case of ordinary bricks, 9 in. by 4½ in. by 3 in. or 2½ in. thick, there shall not be more than ± 1½ per cent. variation in length, nor more than ± 2½ per cent. variation in width or thickness; and in all cases the bricks shall work out their own bond. Special bricks, blocks, or tiles shall not have more than ± 2 per cent variation from any of the specified dimensions.

CEMENT CLAY.

6. This shall be machine ground, and at the discretion of the manufacturer may contain a suitable percentage of fine grog. But in all cases the cement clay shall be quite suitable for the purposes of binding together the bricks, blocks or tiles for which it is supplied, and shall be capable of withstanding the same test for refractoriness.

INSPECTION AND TESTING.

7. The engineer (or purchaser), or his agreed representative, shall have access to the works of the maker at any reasonable time, and shall be at liberty to inspect the manufacture at any stage, and to reject any material which does not conform to the terms of this specification. Pieces representative of the bulk may be selected for the purpose of testing either before or after delivery; but in every case a representative of the maker shall, if he choose, be present when such selection is made, and shall be supplied with a similar piece of the material to that taken for the purpose of testing.

Any complaint as to quality of material to be made by the purchaser before the expiration of ten days after delivery.

If the engineer (or purchaser) and the maker are not prepared to accept each other's tests, they shall agree to submit the samples for testing to an independent authority, to be mutually agreed upon; and the engineer (or purchaser) reserves to himself the right, if the material does not conform to the tests laid down in the specification, to reject any or all the material in the consignment from which the test pieces were taken.

The cost of these independent tests, and of any bricks, blocks, or tiles, damaged before delivery for obtaining test pieces, shall be equally divided between the purchaser and the maker, if the test proves satisfactory; and if unsatisfactory, such cost, and that for all other subsequent tests required on this account from the same consignment, shall be borne by the makers.

The cost of any tests of or any material damaged for the purpose of obtaining test pieces after delivery shall be borne by the purchaser in the event of the test being satisfactory, and, if unsatisfactory, by the manufacturer, in a similar manner to that specified for the tests prior to delivery.

APPENDIX AND NOTES.

REFRACTORINESS

Clause 1.—For general remarks and suggestions for testing, also table for softening temperatures of Seger cones, *vide* appendices of Sections 1 and 2. The cones should in all cases be placed relative to the sample, so that both are subjected to the same temperature.

CONTRACTION OR EXPANSION.

Clause 2.—For general remarks, *vide* appendices of Sections 1 and 2. As soon as cone 12 has squatted, it ceases to furnish any further indication of the temperature of the muffle; so that the subsequent temperatures should be ascertained, at about 15-minute intervals, by means of a pyrometer. It is essential, however, that the temperature should be maintained constant; and if it is necessary to remove plugs, etc., for the purpose of obtaining the temperature, great care must be taken to avoid cooling the furnace by such means. As in the test for refractoriness, the cone should be placed in such a position relative to the sample under test, that both may be subjected to the same temperature.

INSPECTION AND TESTING.

Clause 7.—It has been pointed out by the representatives of the manufacturers that, owing to the high cost of carriage, they may be involved in serious loss if material is extensively condemned after delivery. They agree that the purchaser must have entire freedom to test, and reject, if necessary, any material delivered to him; but it is suggested that until all the manufacturers have suitable arrangements and appliances for constantly testing their goods, it may be possible to render them some assistance by allowing a fairly large sample of their material to be sent in for testing and general approval before extensive deliveries are made. This is in no way, however, to be construed as removing the right of the purchaser to test material in any subsequent consignment.

The Chemical and Mechanical Relations of Iron, Vanadium, and Carbon.*

By J. O. Arnold, D.Met., and A. A. Read, M.Met.
(Professors of Metallurgy in the Universities of Sheffield and Wales respectively.)

The influence of vanadium on iron and steel was discovered by one of the authors in the steelworks of Sheffield University during a series of researches carried out from 1899 to 1902. The experiments were made on ingots melted by the Huntsman crucible process, and in the acid open-hearth furnace. The results were not published in any journal, but were copyrighted at Stationers' Hall. The influence of vanadium, *per se*, was not very marked on structural steel, but in the presence of chromium, nickel, and tungsten, the results were almost magical. On tool steel, *per se*, and with other elements, the results were startling. It was pointed out that as the carbide residue on dissolving the steel in dilute sulphuric acid contained nearly all the vanadium, this

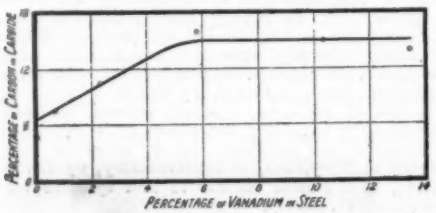


Fig. 1.

element probably existed in the form of a carbide, or double carbide; but so far no systematic research has been carried out to determine the exact condition in which vanadium may be present in steel. The present communication is a continuation of the work published by the authors in their Papers on "The Chemical Relations of Carbon and Iron,"** "The Chemical and Mechanical Relations of Iron, Manganese, and Carbon,"† and "The Chemical and Mechanical Relations of Iron, Chromium, and Carbon,"‡ and contains an account of a number of experiments made to determine :—(1) The composition

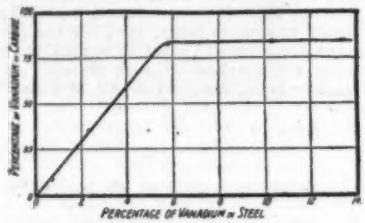


Fig. 2.

of the carbides separated from a series of well-annealed steels containing various percentages of vanadium, the percentage of carbon increasing with the percentage of vanadium; (2) the mechanical properties of the alloys under static and alternating stress tests; (3) the microscopical features of the alloys.

Moissan,* by heating together vanadic anhydride and sugar carbon in different proportions and at various temperatures in the electric furnace, prepared several samples of vanadium containing from 4.4 to 18.42 per cent. of carbon. Moissan also found that, if the heating be prolonged, a crystalline and well-defined carbide, having the formula VC, is always obtained, which scratches quartz with ease, and is not attacked by hydrochloric or sulphuric acids.

Nicolardot† obtained the following double carbides of iron and vanadium; from steels with 0.4

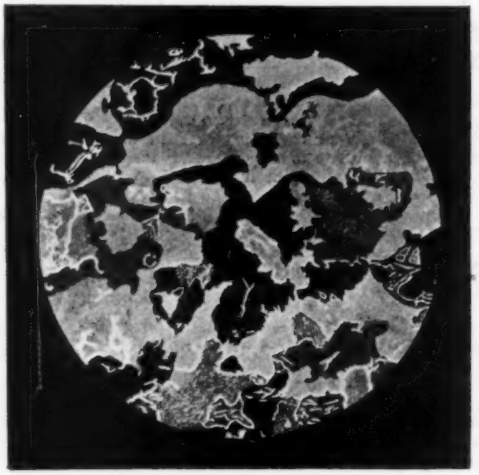


Fig. 3.—Carbon, 0.60 per Cent.; Vanadium, 0.71 per Cent. Magnified 295 Diameters.

per cent. carbon, and 1.5 per cent. vanadium, $Fe_3C,38(V_2C_2)$; from steels containing 0.8 per cent. carbon and 10 per cent. vanadium, $Fe_3C,60\ (V_4C_3)$; and from ferro-vanadium with 9 per cent. carbon and 32 per cent. vanadium, $Fe_3C.74(V_4C_3)$. He also states that the carbide of vanadium becomes richer in carbon as the vanadium content of the alloy and the temperature of preparation is raised, and points out that this increasing amount of carbon found with the vanadium, as the temperature rises, confirms the results previously obtained by Moissan.

Guillet‡ has examined microscopically two series of vanadium steels as forged, and has also determined their mechanical properties. The constitution, the effect of annealing, and the mechanical properties of

* *Paper presented before the Iron and Steel Institute*, 1912.
** *Transactions of the Chemical Society*, 1894, p. 788.
† *Journal of the Iron and Steel Institute*, 1910, No. I. 169.
‡ *Ibid.*, 1911, No. I., p. 249. (*Ibid.*, May 12, 1911).

* *The Electric Furnace*, 1904, p. 169 *et seq.*
† *Le Vanadium*, 1905, p. 147.
‡ *Journal of the Iron and Steel Institute*, 1906, No. II., p. 13, and *Etude Industrielle des Alliages Métalliques*, p. 344.

the two series of vanadium steels, are described by him as follows :—

Constitution.

Groups.	Micro-structure.	Carbon 0.20 per cent.	Carbon 0.80 per cent.
1	Pearlite	Vanadium<0.7	Vanadium<0.5
2	Pearlite and Carbide	0.7<Vanadium<3	0.5<Vanadium<7
3	Carbide	Vanadium>3	Vanadium>7

Annealing as a general rule softens vanadium steels. In the pearlitic steels which contain much

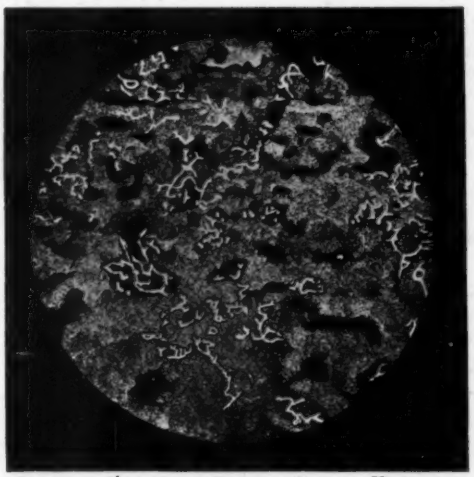


FIG. 4.—CARBON, 0.63 PER CENT.; VANADIUM, 2.32 PER CENT. MAGNIFIED 295 DIAMETERS.

carbide, the carbon is precipitated as graphite, but steels with the carbide show only a slight modification

Mechanical Properties.—Pearlitic steels have a tensile strength and an elastic limit which rise rapidly with the percentage of vanadium; the elongation and reduction of area slowly decrease, while still preserving relatively high values; the brittleness does not increase; the hardness increases rapidly.

Pearlitic and carbide steels have a tensile strength and an elastic limit which are lower in proportion as the percentage of vanadium, and consequently the amount of the carbide, increases; the elongation and reduction of area increase, but the resistance to shock diminishes rapidly. Steels containing the carbide have high elongations and reductions of areas, but they are very brittle.

Paul Putz* prepared a number of steels with vanadium increasing to 1.64 per cent., and carbon increasing to 2 per cent. The results of numerous tensile tests, and the examination of the sections of the steels of this series, are described. The chemical formula for the vanadium carbide present in vanadium steels is stated to be V_2C_3, or $V_2{}_nC_3$

Kent Smith† describes his investigations on the properties of vanadium steels, and gives a summary of the effect of different quantities of vanadium on the static qualities of steel.

Giesen‡ states that it is very difficult to judge correctly sections of vanadium steels under the microscope, since even a low vanadium content is completely dissolved by ferrite, the solution becoming saturated when the vanadium reaches 0.6 per cent. Above this quantity the vanadium unites with the pearlitic carbon to form a vanadium carbide, which comes into prominence as the vanadium in the steel increases.

Portevin,§ working on steels containing 0.2 per cent. carbon and from 0.6 to 0.7 per cent. vanadium, and also 0.8 per cent. carbon, and from 0.25 to 10 per cent. vanadium, arranges the vanadium steels in three groups—

1st Group.—Pearlitic steels.
2nd ,, Pearlitic and double carbide steels.
3rd ,, Double carbide steels.

Hatfield,‖ from his experiments on the influence of vanadium upon the physical properties of cast irons, comes to the following conclusions, amongst others—that silicon is partially prevented from crystallising with the carbide by vanadium, and that by the presence of much of the vanadium in the carbide, the carbide is rendered more stable.

Method of Manufacture of the Authors' Steels.

The alloys were made by the coke crucible process in Sheffield white clay pots from Swedish bar iron, American washed iron, and 38 per cent. ferro-vanadium; 0.05 per cent. of metallic aluminium was added to each a few minutes before teeming. The ingots, 2¾ in. square, and each weighing 40 lbs., were cogged and hammered into bars 1⅛ in. round. The bars were heated to about 950 deg. C. for six hours, and were allowed to cool during an additional twelve hours.

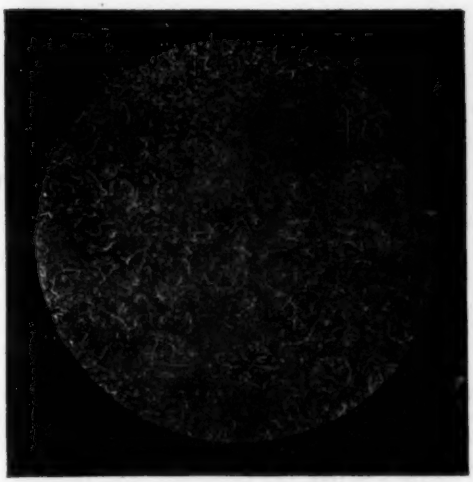


FIG. 5.—CARBON, 0.93 PER CENT.; VANADIUM, 5.84 PER CENT. MAGNIFIED 295 DIAMETERS.

Chemical Compositions of Authors' Series.

The analyses of the steels were made on the last turnings from the carbide bars. The results are given in Table I.

Determinations of the Carbides.

The method and treatment used for separating the carbides was the same as described in the authors' last Paper already referred to, but with this modification, that the residues were dried at 100 deg. C.

* *Metallurgie*, 1906, p. 651.
† *Journal of the Society of Chemical Industry*, 1906, p. 291.
‡ *Journal of the Iron and Steel Institute, Carnegie Scholarship Memoirs*, vol. i. 1909, p. 33.
§ *Journal of the Iron and Steel Institute, Carnegie Scholarship Memoirs*, vol. i., p. 333.
‖ *Journal of the Iron and Steel Institute*, 1911, No. I., p. 318.

in a current of hydrogen, the tube being pumped out from time to time. The steels dissolved quite readily, and with each member of the series vanadium was found in the hydrochloric acid solutions; but in most cases it was quite unnecessary to test for vanadium, as the electrolyte was distinctly blue to dark blue in colour.

The carbides obtained from Nos. 1315 and 1316, containing 0.71 and 2.32 per cent. of vanadium, were

TABLE I.

Number of Steel.	Carbon per cent.	Vanadium per cent.	Silicon per cent.	Phosphorus per cent.	Manganese per cent.	Sulphur per cent.	Aluminium per cent.
1315	0·60	0.71	0.05	0.01	0.06	0.04 or under	Under 0.01
1316	0.63	2.32	0.09	0.01	0.07		
1309	0.93	5.84	0.21	0.02	0.11		
1310	1.07	10.30	0.32	0.03	0.12		
1312	1.10	13.45	0.47	0.03	0.12		

dark grey; and from Nos. 1309, 1310, and 1312, containing 5.84, 10.30, and 13.45 per cent. of vanadium, slate grey in colour.

The analyses of the carbides were carried out as follows:—The porcelain boat containing the dried carbide was weighed. About one-half of the carbide was carefully removed and put on one side for the determination of iron and vanadium. The boat was again weighed, the carbide well mixed with pure manganese dioxide, and the carbon estimated by direct combustion. The remaining portion of the carbide was intimately mixed with sodium carbonate and a small quantity of sodium peroxide in a platinum basin, and heated in a muffle furnace. When cold the mass was repeatedly boiled with water and filtered. The vanadium in the filtrate was estimated by reducing with sulphurous acid and titrating with a standard solution of potassium permanganate. The residue on the filter paper was dissolved in hydrochloric acid and made up to a known volume. The iron was then estimated by the usual volumetric process, using a standard solution of potassium bichromate for the titration. The very small quantity of vanadium found in the iron solution was determined by the hydrogen peroxide colour test. The results are given in Table II.

A consideration of the results in Table II. indicates that in most cases practically the total amount of carbon in the steel is obtained as carbide. The slightly lower results are not due to any appreciable decomposition of the carbide during the electrolytic run, but are accounted for by a slight roughness of the bars which prevented the last traces of carbide being obtained.

The results given in Table II. also show that vanadium replaces iron in the carbide, even when the steel contains only such a small quantity as 0.71 per cent. of vanadium, with the formation of a mechanical mixture of the carbides of iron and vanadium corresponding to the formula $11Fe_3C + V_4C_3$.

As the vanadium in the steel increases, more vanadium is found in the carbide, and with the next member of the series, containing 2.32 per cent. of vanadium, the carbide is represented by the formula $2Fe_3C + V_4C_3$.

Coming to the remaining three steels of the series, with 5.84, 10.30, and 13.45 per cent. of vanadium, in each case practically the whole of the iron has been replaced by vanadium, and most probably a definite carbide of vanadium is obtained, corresponding to the formula V_4C_3.*

TABLE II.

No. of Steel.	Carbon per Cent.	Vanadium per Cent.	Amperes.	Volts at Terminals.	Time in Acid.	Grammes Dissolved.	Weight of Dry Residue.	Percentage of Total Carbon obtained with Carbide Residue.	Analysis of Carbide.			Corresponding to the Formula.	Theory.		
									Carbon per Cent.	Iron per Cent.	Vanadium per Cent.		Carbon per Cent.	Iron per Cent.	Vanadium per Cent.
1315	0·60	0·71	0·5	0·6 to 1·5	12 hours	8·930	0·6753	95·77	7·61	83·71	8·68	$11Fe_3C+V_4C_3$	7·57	83·24	9·19
,,	,,	,,	,,	,,	,,	8·926	0·6847	96·98	7·66	83·09	8·65				
,,	,,	,,	,,	,,	11 hours	8·260	0·6154	92·71	7·49	83·27	9·24				
1316	0·63	2·32	,,	0·7 to 1·2	,,	8·054	0·4346	88·10	10·66	54·60	34·74	$2Fe_3C+V_4C_3$	10·00	56·00	34·00
,,	,,	,,	,,	,,	,,	8·053	0·4148	82·80	10·44	54·71	34·85				
,,	,,	,,	0·55	,,	10 hours	7·630	0·4180	91·20	10·63	53·30	36·07				
1309	0·93	5·84	0·5	0·8 to 1·3	12 hours	8·625	0·5066[1]	99·15	15·94	0·54	83·52	V_4C_3	15·00	...	85·00
,,	,,	,,	,,	,,	,,	8·612	0·4973[1]	98·19	15·94	0·47	83·59				
,,	,,	,,	,,	,,	,,	8·313	0·4890	97·63	16·05	0·83	83·12				
1310	1·07	10·30	,,	0·8 to 1·4	,,	8·168	0·5963	96·76	15·03	1·04	83·93				
,,	,,	,,	,,	,,	,,	8·160	0·5732[1]	95·22	15·00	0·63	84·37				
1312	1·10	13·45	,,	0·8 to 1·6	,,	8·363	0·6787[1]	99·78	14·12	0·82	85·06				
,,	,,	,,	,,	,,	,,	8·571	0·7267	99·06	13·76	1·27	84·97				

[1] These carbide residues were boiled for one hour with dilute sulphuric acid (1 of acid to 10 of water), then washed, treated, and dried in the usual way.

These results are shown more clearly in Figs. 1 and 2. It will be noticed (Table II.) that it is possible to reduce still further this small quantity of iron found with the vanadium by digesting the carbide residues with hot dilute sulphuric acid.

Turning Characteristics of the Alloys.

The report of Mr. J. Harrison, Laboratory Engineer in the Metallurgical Department of Sheffield

TABLE III.

Steel No. A.	Carbon per cent.	Vanadium per cent.	Turning Report.
1315	0.60	0.71	Tough.
1316	0.63	2.32	,,
1309	0.93	5.84	Tough and slightly hard.
1310	1.07	10.30	,,
1312	1.10	13.45	,, Tough and ,, hard.

University, on the behaviour of the bars in the lathe is embodied in Table III., the word tough having

* It is theoretically possible that this may be a mixture of vanadium carbides.

reference to the capability of the material to curl off in spirals during the turning operations.

Mechanical Properties.

The static results are embodied in Table IV., the test-pieces being 2-in. parallel and 0.564-in. diameter.

TABLE IV.—*Tensile Tests.*

Steel No. A.	Yield Point. Tons. per sq. inch.	Max. Stress. Tons per sq. inch.	Elongation. per cent.	Reduction of Area per cent.
1315	12.0	35.9	22.0	41.4
1316	14.0	35.0	24.5	52.0
1309	17.0	33.4	25.0	53.2
1310	15.0	33.7	23.0	31.5
1312	18.0	37.0	10.0	9.7

Since 1309 contains 0.93 per cent. of carbon, its test result is remarkable.

Alternating Stress Tests.

The dynamic tests obtained under standard conditions on the Arnold machine are tabulated in Table V.

TABLE V.—*Alternating Tests.*

Steel No. A.	Alternations Endured.		
	1st Test.	2nd Test.	Mean.
1315	126	112	119
1316	162	220	191
1309	144	126	135
1310	94	144	119
1312	8	22	15

The poor dynamic properties of the series exemplify the evil influence of drastic annealing on vanadium steels.

Micrographic Analysis.

The microscopical examination of the steels leads the authors to announce provisionally the discovery of two new constituents—1. Vanadium pearlite; 2. Vanadium cementite, V_4C_3.

(1) *Vanadium Pearlite.*—This constituent seems incapable of segregating into the laminated variety, and presents itself only in the troostitic and sorbitic forms. Its saturation point seems considerably higher than that of iron pearlite, but this point requires further research.

(2) *Vanadium Cementite.*—This constituent (a decomposition product of vanadium pearlite) is not nearly so mobile as Fe_3C, and consequently segregates into relatively minute irregular masses very much smaller than massive iron cementite.

The micrographic analysis has proved—almost beyond doubt—that there is no double carbide of iron and vanadium, since when Fe_3C and V_4C_3 are together in a well annealed steel the former has segregated as usual, whilst the latter has remained distributed in its pearlite in the troostitic or sorbitic form.

Micrograph (*Fig.* 3).—In this structure was found (*a*) a pale ground-mass of slightly vanadiferous ferrite; (*b*) a few areas of laminated iron pearlite; (*c*) the Fe_3C of decomposed laminated iron pearlite in the form of cell walls and irregular masses; (*d*) dark etching troostitic vanadium pearlite; (*e*) less-dark etching areas of sorbitic vanadium pearlite. This section contains 0.6 per cent. of carbon and 0.71 per cent. of vanadium.

Micrograph (*Fig.* 4).—This steel presents a very confused structure in which vanadiferous ferrite and vanadium pearlite in both the troostitic and sorbitic forms have segregated very imperfectly in spite of the twelve hours cooling. The only well-defined constituent is the iron cementite, which has readily segregated in meshes and masses, but is distinctly less in quantity than that in Fig. 3. The steel represented in Fig. 4 contains 0.63 per cent. carbon and 2.32 per cent. vanadium.

Micrograph (*Fig.* 5).—This section consists largely of sorbitic vanadium pearlite, overlaid, however, by irregular meshes, apparently of vanadiferous ferrite. In other words, the steel is not saturated. It contains 0.93 per cent. carbon, and 5.84 per cent. vanadium.

Micrograph (*Fig.* 6).—This contains 1.10 per cent. carbon, and 13.45 per cent. vanadium. It is almost identical in structure with steel No. 1310, which contains 1.07 per cent. carbon and 10.30 per cent. vanadium. The ground-mass is vanadiferous ferrite, over which are scattered small segregated irregular masses of vanadium cementite, V_4C_3. Each particle is environed by a somewhat dark border of probably sorbitic vanadium pearlite, and small patches and streaks of this constituent are also scattered over the field. The mobility or segregative capacity of V_4C_3 obviously increases with the percentage of vanadium present in the ferrite.

In conclusion, the authors have to tender their thanks to Mr. F. K. Knowles, B.Met., Senior Lecturer in Metallurgy at the University of Sheffield, for much valuable help in making the steel and mechanical tests; also to Mr. Duncan Maxfield, Associate in Metallurgy of Sheffield University, for the patience and accuracy of his work connected with the chemical branch of the research. Finally, the authors have to thank Mr. E. Colver-Glauert, Research Assistant in the University of Sheffield, for his exquisite micrometric reproductions of the four typical micrographs illustrating this Paper.*

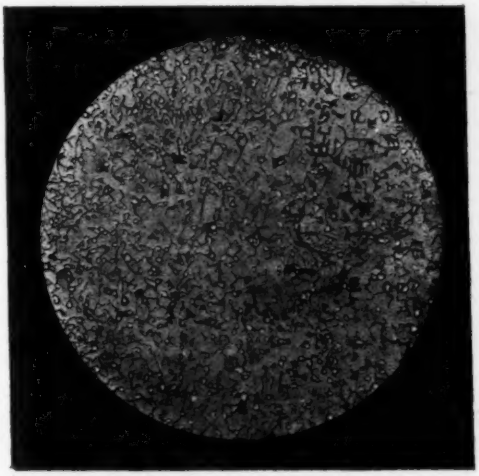


FIG. 6.—CARBON, 1.10 PER CENT.; VANADIUM, 13.45 PER CENT. MAGNIFIED 295 DIAMETERS.

The authors hope at no distant date to report to the Institute on the chemical and mechanical relations of iron carbon and nickel. In view of a suggestion made at the last May meeting of the Institute by their friend Dr. Stead, the authors wish to state that the absorption and recalescence curves of the steels dealt with in all their carbide researches will be included in a special Paper as soon as possible after the unique recalescence laboratory now being fitted up for the Sheffield University by the Cambridge Scientific Instrument Company is available for work.

* The term "sorbitic," as used in this Paper, has reference to pearlite, in which the carbide, although in a fine state of division, is nevertheless within the range of microscopic vision. The term "troostitic" has reference to pearlite, in which the carbide is in a state of division so fine as to be beyond the range of microscopic vision.

APPENDIX.

Important Note.

Since writing this Paper, the authors during recalescence observations have provisionally to announce a discovery of far-reaching theoretical importance.

Steel No. 1316.—*Carbon*, 0.63 *per cent.*; *Vanadium*, 2.32 *per cent.*

Cooled from 1,020 deg. C., this steel did not present the point Ar3. Ar2 appeared at 791 deg. C. and Ar1 at 720 deg. C. This latter point was very small for a 0.63 per cent. carbon steel.

Steel No. 1310.—*Carbon*, 1.07 *per cent.*; *Vanadium*, 10.3 *per cent.*

Cooled from 1,210 deg. C., this steel failed to present the point Ar3. Ar2 presented the top peak at 830 deg. C., and the lower peak at 816 deg. C. Ar1 was quite absent. On heating, the maximum absorption at Ac2 was at 826 deg. C., Ac1 was absent.

Quenching Experiments.

Samples of steel No. 1310, carbon 1.07 per cent., vanadium 10.3 per cent., were rapidly quenched from the following temperatures: 850 deg. C., 1,000 deg. C., and 1,050 deg. C. All after quenching were quite soft to the file. The authors provisionally draw the following conclusions:—

(*a*) That the point Ar1, marking the formation of vanadium pearlite from vanadium hardenite, must be between 1,200 deg. C., and 1,400 deg. C. (the latter being about the solidification point of the steel). When quenched in water from about 1,300 deg. C., steel No. 1310 was quite hard, stripping a new file.

(*b*) That although the steel be quenched in the beta range of temperature, it is still quite soft.

(*c*) That the above conclusions, when fully confirmed, will form direct proof of the correctness of the views so long held by Professor Le Chatelier, Sir Robert Hadfield, Dr. McWilliam, and the authors, that the hardening of steel is brought about by carbon in some form irrespective of the range of temperature.

Further experiments have resulted in the discovery of vanadium hardenite, which is formed near 1,400 deg. C. It resembles iron hardenite, but seems as hard as topaz.

The authors have to thank Mr. F. C. Thompson, B.Met., Demonstrator of Metallurgy in Sheffield University, for his services in carrying out the foregoing experiments.

Investigation on Efficiency of Brass Melting Furnaces.

The United States Bureau of Mines proposes to investigate the efficiency of brass-melting furnaces, with the idea of improving, if possible, on present types, and particularly to cut down the oxidation or volatilisation losses of metal. To aid the Bureau in this the Committee appointed by the American Institute of Metals to co-operate with the Bureau is collecting data on the results being obtained by its members in actual practice.

The basis for the figures is a working day for one furnace, as this can probably be the most easily obtained from existing records. The questions to be answered are as follows:—

(1). What is the type of furnace used? (pit, tilting with crucible, tilting without crucible—electric) Maker's name?

(2). Shape and dimensions of furnace?

(3). Lining—Material—Thickness?

(4). Cover—shape and size—material?

(5) Size of crucible used?

(6). What fuel used?

(7). Details of fuel and air supply?

(8). Number of furnaces one furnace tender can handle (on basis of red brass)?

(9). Amount of fuel used per furnace per day—lbs. of coal or coke, gallons of oil, cubic feet of gas, kw.-hours of electricity?

(10). Number of heats per working day?

(11). Hours per working day for furnace—from time cold furnace is started till day is over?

(12). How often are furnaces relined, or other repairs made?

(13). How many heats in the life of a crucible?

(14). Total lbs. metal charged per day per furnace,—lbs. composition ingot; lbs. new metal; lbs. gates and sprues; lbs. borings; lbs. other scrap.

(15). Total lbs. metal poured per day per furnace—deducting all losses by oxidation or volatilisation, or in the slag or skimmings.

(16). Total lbs. metal recovered from slag, skimmings, etc., per furnace per day.

(17). Gross percentage of loss during melting.

(18). Net percentage of loss during melting, taking account of metal recovered from all metal-bearing refuse.

(19). Average analysis of alloy produced.

(20). Answer Questions 8 to 19 also for yellow brass—manganese bronze or any other brass or bronze you have figures on.

(21). Are your figures based on a single day's run, or are they averages? If the latter, on how long a period is the average based?

(22). Discuss the relative advantages and disadvantages of the various types of furnaces you have tried. Is there any difference in the quality of the metal melted in various furnaces either on physical tests, pressure tests, or as to its behaviour in the foundry?

(23). What precautions are taken to secure immunity of employés from accident, poisoning or occupational disease?

(24). To what extent are employés subject to "Brass Shakes," lead poisoning, etc.?

(25). What precautions are taken to lay or remove poisonous fumes or irritating dust, to which employés may be exposed?

(26). Do you post notices and give instructions to employés in regard to hazards to which they may be subject? If so, please send copies of notices and of instructions.

(27). Please give any information along these lines you can, that has not already been brought out by the questions.

Replies, so far as they apply to individual plants, will be held confidential by the Committee and by the Bureau of Mines. Members replying to this list of questions will be placed on the mailing list for announcements from the Bureau of Mines, and will receive bulletins containing reports of the investigations on non-ferrous alloys on request.

Replies should be sent to the Chairman of the Committee, Mr. H. W. Gillett, No. 84, Euclid Avenue, E., Detroit, Mich., U.S.A.

The partnership heretofore subsisting between Messrs. A. Raybould and S. Huxley, carrying on business as brass founders and manufacturers of gas and electric fittings, at 9 and 11, Fleet Street, Birmingham, under the style of the Fleet Brass Company, has been dissolved.

Pattern for a Motor Shell.

The motor shell casting shown in Figs. 1 and 2 has now become a familiar object of manufacture, and is made either of cast steel or cast iron. In the case of the former it is necessary to use metal of a non-magnetic nature somewhat similar to wrought iron, and in the latter extra thickness is required if the best results are to be obtained electrically from a permeability point of view. Both kinds are made, but in either case it is a matter of utility and, to a large extent, dependent on the electrical engineer.

The pattern described in this article was made for cast steel. There is no difference in the making of the pattern for iron or steel except in so far as the preparation for the casting head is concerned, the

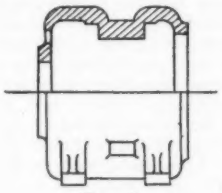


FIG. 1.

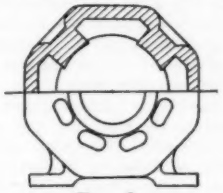


FIG. 2.

one for steel being made much deeper than the one for iron, the abnormal head being required for feeding purposes.

It may here be remarked, regarding the designing of these shells, that it is advisable to have all the sections of metal equal; but as it is not always possible, the next best thing is to avoid abrupt changes and make the transitions from the thick to the thin gradual. The nature of the precautions to be taken by the moulder will be treated later on.

There are no difficulties to be overcome in the making of the pattern, but one or two features about it might be mentioned. Figs. 3 and 4 will give some idea as to the construction. The body is built up with staves, the cross-stays and end pieces being

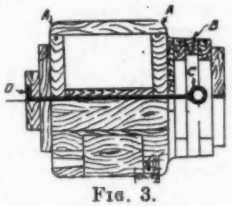


FIG. 3.

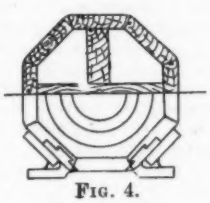


FIG. 4.

of liberal thickness, the former to allow for the formation of the corners A A Fig. 3, and the latter to stiffen the pattern for the rapping and lifting plates. The full-size lay-out, which it is usual to make for jobs of this kind, will show the thickness necessary for the end pieces.

Seeing that the pattern is moulded on end, it is necessary to have the two bottom feet loose; one of these is shown in Fig. 5. Only one pattern for the

FIG. 5.

feet was made and four aluminium ones cast from it; the two which required to be fixtures on the pattern were made with plain backs, the other two being arranged with dovetail pieces to hold them in position whilst being rammed up. One reason for having the feet made of metal was on account of the constant repairs necessary through them getting broken. Moreover, apart from the cost of the metal, there is little or no difference in the initial cost, but there has been a good saving in repairs.

The portion of pattern marked B, Fig. 3, is also left loose to be lifted away in the cope. It will be noticed that this portion is not shown as part of

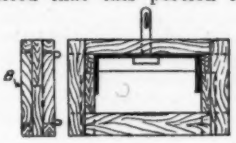


FIG. 6.

FIG. 7.

the finished casting, but it is necessary to be cast on, as already stated, to act as a feeding head. These heads are either sawn or machined off in the fettling shop. Fig. 3 also shows the method of using the lifting eye-bolt C; this is arranged to pass through the pattern and screw into the plate D.

Figs. 6, 7, 8, and 9 show the construction of the body core-box. This is made in two halves, and as it is important that the four-pole pieces should be equidistant when finished, extra precautions are

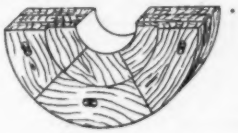


FIG. 8.

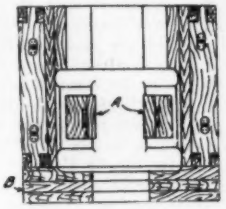


FIG. 9.

taken to have them secure whilst being rammed. With this object in view only the undercut portions A, Figs. 7 and 9, are made loose; this enables the major part of the pole piece to be fastened to the box so that

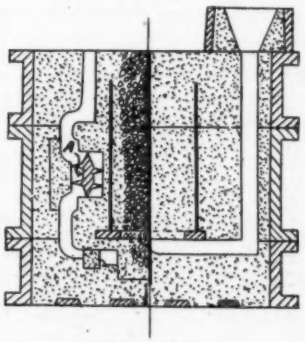


FIG. 10.

FIG. 11.

there is no question of moving when the core is being made.

The part B, Figs. 6 and 9, and in elevation Fig. 8, is made separate for the convenience of the coremaker, who is thus better able to arrange the core-iron and make the core generally. This core must be

made to give as little resistance as possible to the contraction of the casting. To do this the centre is filled in with a liberal supply of cinders, etc.

The left-hand side of Fig. 10 shows a half-section of the mould with the cores in position; the piece marked A in the centre of the pole is termed a "dummy," that is a small casting placed in that part to help to solidify the excessive lump of metal at that place, and which it is not possible to conveniently feed any other way. The right-hand shows a section of the runner gate, the bottom of the gate entering on a tangent to the diameter of the casting

Fig. 11 shows the construction of the core-iron. An open sand mould is made for the ring, the wrought-iron stakes and lifting rods are pressed into the sand and then the metal ring cast around them.

Finally, to get the best casting and free from flaws, the core should be eased as soon as possible after pouring.

The Electric Furnace as a Possible Means of Producing an Improved Quality of Steel.

By William R. Walker (United States Steel Corporation).

In the manufacture of steel by either the Bessemer or open-hearth process, it is very difficult to remove the last traces of oxygen. In the basic Bessemer process, the over-blown metal, which is an extreme case of oxidation, contains only 0.06 per cent. of oxygen. Oxygen, in combination with carbon (carbon monoxide), silicon, iron, aluminium and manganese, and also the combinations of silicates with these oxides, are very deleterious in steel.

My investigations lead me to believe that in the manufacture of steel for the so-called heavy products and steel that is produced in large quantities, a combination of either the acid or basic Bessemer converter and the electric furnace will take a very prominent place. With this combination, it is possible to produce steel extremely low in oxygen and other impurities at a cost that will not be too prohibitive.

At the present time there are over 70 electric furnaces of various types producing electric steel in Europe and America. These range in capacity from 1 to 15 tons. There is now under construction in Germany a furnace of 25 tons' capacity. A number of these furnaces are competing successfully with crucibles in the manufacture of very high-grade steel.

Generally speaking, electric furnaces may be divided into two groups:—(1). Induction furnaces, in which the heat is supplied by a current induced in the bath. (2). Arc furnaces, in which the arc is struck, either between an electrode and the metal in the bath, or between two or more electrodes, so as to heat the metal only by radiation from the arc.

In operating the electric furnace at the present time, the most prominent methods or combinations are as follows:—

1. Oxidation of silicon, carbon and manganese in an acid-lined Bessemer converter, and removing the phosphorus in the basic-lined electric furnace with an oxidising slag, and then recarburising, and with the aid of manganese and carbon and a new reducing slag removing oxygen and sulphur, and dead melting as in the crucible process.

2. Removal of silicon, carbon, manganese and phosphorus in a basic-lined Bessemer converter and further removing phosphorus (if desired) in the basic-lined electric furnace with an oxidising slag, and then with the aid of manganese and carbon and a new reducing slag removing oxygen and sulphur, and dead melting as in the crucible process.

3. Removal of silicon, carbon, manganese and phosphorus in the basic open-hearth furnace and then recarburising, and in the basic-lined electric furnace with the aid of manganese and carbon and a new reducing slag removing oxygen and sulphur, and dead melting as in the crucible process.

4. Melting of cold scrap of inferior quality in a basic-lined electric furnace; removing phosphorus with an oxidising slag and then recarburising, and with the aid of manganese and carbon and with a new reducing slag removing oxygen and sulphur, and dead melting as in the crucible process.

5. Melting high-grade materials in the electric furnace, and dead melting as in the crucible process.

The phosphorus is removed in the basic electric furnace in the same manner as in the basic open-hearth furnace—that is, by the use of lime and oxide of iron—and the resulting slag containing the phosphorus is removed and a new slag formed consisting of burnt lime and fluorspar; and when the slag is melted, coke dust is added, which, coming in contact with the lime in the slag and the electric arc, produces carbide of calcium. The free carbon, and possibly the carbide of calcium in the slag, with the aid of carbon and manganese in the bath, eliminate the oxygen from the steel.

As compared with the Bessemer and basic open-hearth processes, the electric has the following advantages:—(1) The more complete removal of oxygen. (2) The absence of oxides caused by the additions, such as silicon, manganese, etc. (3) The production of electric steel ingots of eight tons in weight and smaller that are practically free from segregation. (4) Reduction of sulphur to 0.005 per cent., if desired. (5) Reduction of phosphorus to 0.005 per cent., as in the basic open-hearth process, but with the complete removal of oxygen.

As evidence of the reducing properties of the slag in the basic electric furnace, it has been found that if oxide of manganese and oxide of iron are thrown on the molten slag, the oxides are reduced to the metallic state and the reduced metal goes into the bath. Blown metal from the acid Bessemer converter, containing only 0.10 per cent. to 0.20 per cent. manganese, has been completely deoxidised in the electric furnace without addition of manganese or aluminium, the usual amount of silicon being added in the steel ladle. The composition of one heat of this steel is as follows:—Carbon, 0.55 per cent.; manganese, 0.13 per cent.; sulphur, 0.017 per cent.; silicon, 0.19 per cent.; phosphorus, 0.022 per cent.

On account of the wide variation in the chemical composition of this steel, it would, in a Paper of this nature, and with the limited time at my disposal, be difficult, without going into considerable detail, to discuss the physical properties. It might be stated, however, that electric steel of a given tensile strength has a slightly greater amount of elongation than basic open-hearth steel, and that electric steel is somewhat denser than basic open-hearth or Bessemer steel.

With the electric furnace it is possible to produce steel which, when magnified one thousand diameters, shows no oxides or slag enclosures. As high-grade electric steel can be produced at a lower cost than crucible steel, there has been a gradual increase in the production of electric steel for certain purposes where crucible steel was formerly employed, and where it has been demonstrated electric steel can be successfully used.

The Judicious Use of Cheap Metals in the Brass Foundry.

By A. Napier.

In the general discussions on brass foundry practice which take place from time to time, stress is often laid on the desirability of using good materials, and some enthusiasts (usually not employers, but those doing the work) go so far as to advocate careful analysis of all raw materials to ensure the maintenance of a high standard of purity and successful casting. Where the work is of a closely defined character, and has to meet stringent specifications, there is little question about the desirability of ascertaining that the quality of the raw materials is maintained; for with standardised foundry procedure for the production of high-class castings defective raw materials may readily upset all the calculations of the foundryman, and largely discount the care of both melter and moulder. Since also, poor materials are often supplied to the unwary purchaser at the cost of first-class materials, and as some purchasing departments of foundries are often very loth to admit the possibility of error on their part, the foundryman may be placed in the awkward position of not having the proper raw materials for his work, and not being able to insist on the fact in the disputes which almost unavoidably arise. Now, while it is granted that for certain classes of work only the best raw materials should be used, this is an expensive procedure and cannot be countenanced for certain other classes of work where competition cuts prices and no strict specification as to composition and mechanical properties has to be met. It is unnecessary to detail any of the great variety of work which comes under the latter category, since every brass founder is familiar with such. Under commercial conditions it is often a matter of importance that the cheapest possible mixture (compatible, of course, with good products of the necessary strength and which will not necessitate an undue proportion of "wasters" or of labour in production) be used for castings, particularly where large quantities are turned out. Where small orders in considerable variety are in hand at once and are to be poured at the same time, it would, of course, be necessary to melt a mixture which would serve the highest requirements, and use that also for the others; but such a situation seldom occurs except in jobbing shops, where the prices are not generally so closely cut. Such cases, however, are not the matter under consideration.

It may be taken as a general rule, then, that cheapness is an important point, and that the nature of the metal largely affects the cost of the castings. It then becomes necessary to adopt some method of calculating the cost of different mixtures, and of computing the saving to be effected through allowable variations in composition. It is obvious that such a calculation will not be the same where the castings are sold by weight as in the case of a price for a definite bulk of metal (a price per piece for castings of a specified size and pattern). Therefore these two classes of orders may here be considered separately.

On receiving an order for a certain class of work it behoves the founder to ascertain carefully, in the absence of definite instructions or specification from the customer, what conditions the castings have to serve, and then to compound his metal with a view to meeting those requirements at the cheapest possible rate. In calculating this work a compilation similar to Table I. should be kept for reference. This table gives the current metal values (altered from time to time as the market changes) and the same values expressed in uniform manner, as, for example in shillings per ton.

TABLE 1.

Specific gravity	Metal.	Current price. £. s. d.	Cost per ton in shillings.	Figure of relative cost per unit of bulk.
8.9	Copper	78 8 0	1,568	13,955
7.3	Tin (Straits)	208 0 0	4,160	30,368
11.3	Lead	18 10 0	370	4,181
7.1	Zinc	26 0 0	520	3,692
6.8	Antimony	27 10 0	550	3,740
2.7	Aluminium	80 0 0	1,600	4,320

The specific gravities of the metals in question should be added as shown, to indicate the relative weight values. This column is not for use where the weight of a given bulk of castings is a consideration in connection with the price, as where sold by weight, but the figures are to be used in conjunction with the current price of the material to calculate the last column, which gives the figures of relative cost per unit of bulk. This is got by multiplying the value denominator by the specific gravity, and shows relative values of the metals for the same bulk, as for example one casting of a given size. This column should not be confused with the actual cost figures.

It is also of great assistance to compile a list of mixtures suitable for given classes of work, with the variations allowable and the approximate mechanical properties of the mixture when cast under the normal conditions of the foundry in question. Such a table would necessarily be the result of considerable experience, but most capable foundrymen have at hand a good deal of knowledge that would make a basis for such a compilation, and this could be supplemented by working results from time to time. This list could be used as a guide, not in calculating the cost, but in indicating the extent to which any mixture could be varied for a given class of work.

Cost when Sold by Weight.

Take now the case of an order for castings where the exact composition of the castings is not specified and where a reasonably wide variation in composition will give the desired strength, as for instance, builders' hardware. A mixture often employed for this is Cu. 66 per cent., Zn. 33 per cent., with Sn. 1 per cent. to stiffen and harden the alloy, and this represents a really first-class mixture for the purpose. But many classes of such work do not require first-class metal and would do quite well in the standard 60:40 metal. It would be advisable in the case of a fairly large mixed order to carefully select those castings requiring the better metal and cast the others with 60:40 metal. The saving on such castings if sold by weight would be calculated

out as follows:—

TABLE 2.

Composition per cent.	Cost denominator (shillings per ton).	Cost of Percentage (shillings per ton).	
Cu. 60 ..	1,568	94,080	
Zn. 40 ..	520	20,800	
100		114,880	per cent. tons.
Cu. 66 ..	1,568	103,488	
Zn. 33 ..	520	17,160	
Sn. 1 ..	4,160	4,160	
100		124,808	per cent. tons.

Since the cost denominator given is per ton, the total of the 60:40 mixture would be 114,880 shillings per 100 tons, or £57 8.8s. per ton, while that of the 66:33:1 would be 124,808 shillings per 100 tons, or £62 8.08s. per ton; the saving in cost of metal on one ton of castings sold by weight would thus be about £5.

In some instances where materially heavier or lighter metals are introduced in quantity the results would be affected more considerably. The introduction of lead to the above alloy would affect the results somewhat in this direction; and lead may often be legitimately used to cheapen a brass mixture. Taking the 60:40 brass mixture above cited, this can well carry 2 to 4 per cent. of lead, and if filing or machining has to be done, the addition is practically a necessity, in order that the metal may work freely. A very useful alloy for some work is:—Cu., 56 per cent.; Zn., 40 per cent.; Pb., 4 per cent. The cost of this works out as follows:—

TABLE 3.

Composition per cent.	Cost denominator.	Cost of percentage.	
Cu. 56 ..	1,568	87,808	
Zn. 40 ..	520	20,800	
Pb. 4 ..	370	1,480	
100		110,088	per cent. tons.

The cost of this alloy is thus 110,088 shillings per 100 tons, or £55 per ton, which shows a saving of £2 8s. per ton over the 60:40 mixture, and of £7 8s. over the 66:33:1 mixture, when the castings are sold on the basis of weight.

Take again an order for aluminium alloy castings where the chief requirement is a good finish and white colour, and lightness (as with many small articles and fittings) is of small account. The use of a Zn. 20-Al. 80 alloy, such as is used to obtain good, strong castings, might readily suggest itself; but it is possible that a Zn. 30-Al. 70 mixture would serve quite as well for the castings in question, without making them unduly weak or brittle for their purpose. On the basis of weight the difference in these two mixtures would work out as follows:—

TABLE 4.

Composition per cent.	Cost denominator.	Cost of percentage.	
Al. 80 ..	1,600	128,000	
Zn. 20 ..	520	10,400	
100		138,400	per cent. tons.
Al. 70 ..	1,600	112,000	
Zn. 30 ..	520	15,600	
100		127,600	per cent. tons.

The first showing a cost of 138,400 shillings per 100 tons or £69 4s. per ton, and the second of £63 16s. per ton, the saving would be £5 8s. per ton—a matter of importance where large quantities are to be handled.

Cases in which the slight adjustment of the mixture within justifiable limits would give an appreciable saving, could be multiplied almost indefinitely; but the foregoing is sufficient to show what can be done. The writer is well aware that the addition of cheaper metals to non-ferrous alloys is largely (and sometimes unwarrantably) practised, but in many cases it is not done systematically, with a view to cheapening the mixture without unduly weakening the castings. There is a tendency to conclude that a few cwts. of castings may as well be poured with a high-grade metal as not, if the melter is used to handling that mixture. The difference on a small lot of castings may not be great, but over a short period with a considerable variety of work the difference is of great importance.

Cost when Sold by Bulk.

When castings are sold by bulk and not by weight the addition of cheapening mixtures must be regarded from a very different point of view. It may seem like labouring an obvious point to insist that the addition of a low-priced heavy metal is not necessarily a source of economy in such cases; but it is a fact which very many founders appear to wholly ignore.

Let us, then, calculate the cost of the Cu. 60: Zn. 40 alloy as compared with the Cu. 66:Zn. 33: Sn. 1 alloy, which showed an advantage of £5 a ton when sold by weight. When calculating the cost on the basis of bulk, the final column of Table I. comes into requisition, the figures representing the relative costs of the different constituents for the same bulk, *i.e.*, the castings to be poured. The calculation of the alloys would then be as follows:—

TABLE 5.

Composition per cent.	Cost denominator per unit of bulk.	Cost of percentage of bulk.	
Cu. 60 ..	13,955	837,300	
Zn. 40 ..	3,692	147,680	
100		984,980	per cent. tons.
Cu. 66 ..	13,955	921,030	
Zn. 33 ..	3,692	121,836	
Sn. 1 ..	30,368	30,368	
100		1,073,234	per cent. tons.

The saving on the basis of bulk, then would be $\frac{88,254}{1,073,234}$, or about 8.2 per cent.—a trifle more (0.2 per cent.) than on the basis of weight, since the saving of £5 on £62 8s. is about 8 per cent. This closeness results from the fact that the specific gravities of the metals in question are not very greatly different.

Take next the addition of 4 per cent. of lead in place of copper; on the basis of bulk the alloy would be valued as follows:—

TABLE 6.

Composition per cent.	Cost denominator per unit of bulk.	Cost of percentage.	
Cu. 56 ..	13,955	781,480	
Zn. 40 ..	3,692	147,680	
Pb. 4 ..	4,181	16,724	
100		945,884	per cent. tons.

The cost of the 60:40 alloy, as before shown, is 984,980 and that of the 66:33:1 alloy 1,073,234. It will be seen that the saving over the latter is $\frac{127,350}{1,073,234}$, or about 11.9 per cent. on the basis of bulk, while on the basis of weight it was 11 per cent. If the lead were added in place of zinc instead of copper the cost would be higher, since the relative value per unit of bulk is higher for lead than for zinc, as indicated in Table I.

Taking next the aluminium-zinc alloy (which showed a saving of £5 8s. a ton on the basis of weight, through the substitution of 10 per cent. zinc for aluminium), it will be found that on the basis of bulk the saving would not be so great, since the cheaper zinc has less than half the bulk of the aluminium. The relative values of these two alloys may be calculated as follows:—

TABLE 7.

Composition per cent.		Cost denominator per unit of bulk.	Cost of percentage.
Al. 80	..	4,320	345,600
Zn. 20	..	3,692	73,840
100			419,440
Al. 70	..	4,320	302.400
Zn. 30	..	3,692	110,760
100			413,160

The saving is thus only about 1.5 per cent. when reckoned on the basis of bulk, though on the basis of weight it is nearly 8 per cent. These facts are worth considerable attention; for while it is shown in what direction a commercial opponent may operate when cutting prices for sales by weight, it will also be seen that there is practically no saving in employing an excess of zinc when simply quoting for bulk or piece. Further, it would appear very necessary for buyers, when obtaining quotations for aluminium alloy castings, either to stipulate the composition or ascertain for what alloy the foundry is quoting; while if the castings are being bought by weight it would be well to calculate the values of the different quotations on the basis before-mentioned for weight values. It would often by this means be found that a seemingly cheap casting is in reality a very dear one. There is no doubt that even in engineering work, owing to the limited knowledge many engineers possess of the light alloys, much material is bought at a high price under the misapprehension that it is a standard aluminium mixture.

It will be obvious, also, on the other hand, that it is foolish for a founder to attempt too great a substitution of aluminium to cheapen a mixture in which strength is a necessity. The saving of 1½ per cent. on the cost by the substitution of 10 per cent. does not justify producing castings that may prove to be below the requirements of its service.

The Valuation of Scrap.

The proper valuation and use of scrap metals is another important point in the economy of metal mixing. When the material in question is simply the foundry's own scrap, and the composition can be gauged within a little, it is a simple matter to correctly value it on the basis of the foregoing calculations and use it accordingly. But where outside scrap is introduced a number of complications arise. Unquestionably the best way to deal with unknown scrap is to reduce it to ingot form and submit representative samples to an analyst. But this is not always convenient, on account of the quantity in question, or other considerations. In such case it is advisable to sort the scrap into its different descriptions, as nearly as can be gauged, and after submitting it to a magnetting test to ascertain whether iron is present (of course separating all metal with iron contained), class it roughly to approximate composition. An expert foundryman can often come very close to the composition of scrap, particularly that of such a nature as usually employs standard mixtures, as drawn or spun work. The copper content is the important point to consider, since that is the dearest of the metals present in large percentage. The values of the different scrap piles could then be calculated roughly, and the metal used on the basis of those figures. Such a calculation would be somewhat as follows:—

TABLE 8.

Scrap pile.		Approximate contents percentage.	Cost denominator (scrap metal).	
A. ..	..	Cu. 70	1,350	94,500
		Other 30	350	10,500
		100		105,000
B. ..	..	Cu. 60	1,350	81,000
		Other 40	350	14,000
		100		95,000
C. ..	..	Cu. 50	1,350	67,500
		Other 50	350	17,500
		100		85,000

The cost denominators, it will be seen, are lower than in the case of new metals, and they must be calculated roughly in relation to the price of new copper and the other metals. Only an approximate figure, of course, can be used.

This method of sorting and classifying the scrap would also give a fair indication of the value of a purchased lot, though it is necessarily a very "rule of thumb" method, and the material could not well be used for good work.

If the scrap is remelted and analysed, and the values recorded as before indicated, it can be employed with certainty in almost any work except where really pure metals are needed. Moreover, such a valuation would form a basis on which to quote for work which could employ that scrap, and could also be used as a check on the price paid for scrap if purchased outside.

When using foundry's own scrap it should be, as far as possible, kept in distinct storage quarters and the approximate composition recorded.

Investigation of Aluminium-Magnesium Alloys.

Writing in "Metallurgie," A. Wilm states that the presence of a small quantity of magnesium makes it possible to harden aluminium, although microscopic examination does not show any structural change of the metal. The hardening is accomplished by heating to 500 degrees, quenching in water, and then allowing to stand. At first the quenched alloy is soft, but after it has stood for a while it becomes harder, stronger, and more ductile, these properties increasing gradually. An alloy heated to 500 degrees and cooled slowly is at first harder than the quenched alloy, but the final product is not as hard. The metal should not be worked directly after hardening. Heating the quenched metal in boiling water makes it like the metal that has been slowly cooled. Heating to 200 degrees causes a distinct loss of hardness. The addition of magnesium to aluminium also increases the hardness and nickel makes the alloy tough.

THE death took place recently of Mr. R. W. Munro, mechanical engineer, Conwall Road, South Tottenham, London, N.

MR. E. TWEEDALE, of Tweedales & Smalley, Limited, Globe Works, Castleton, near Rochdale, died recently, aged 74 years.

THE death is announced of Mr. Henry Lea, head of the firm of Henry Lea & Son, consulting engineers, Bennett's Hill, Birmingham.

THE death is reported of Mr. J. Dunn, formerly assistant director of naval construction at the Admiralty, and later naval director of Vickers, Limited.

Iron and Steel Institute.

Provisional Programme of Leeds Meeting.

In accordance with the announcement made at the May meeting, the Autumn Meeting of the Iron and Steel Institute will be held at Leeds on Monday, Tuesday, Wednesday, Thursday and Friday, September 30 and October 1 to 4, 1912. An influential Reception Committee has been formed with Lord Airedale as chairman, and including also the following:—The Lord Mayor of Leeds (Mr. William Nicholson, J.P.), Mr. R. Armitage, M.P.; the Hon. Rupert Beckett, D.L.; Mr. A. Edmund Butler; Mr. E. Kitson Clark; Mr. F. J. Kitson, J.P.; the Hon. Roland D. Kitson; Mr. M. Mannaberg; Professor M. E. Sadler, C.B. (Vice-Chancellor, Leeds University); Mr. A. T. Tannett-Walker, J.P.; Mr. G. R. T. Taylor; Mr. J. H. Wicksteed, J.P., and Mr. J. F. Walker (Lord Mayor's Secretary) as Hon. Secretary to the Committee. The provisional programme of the meeting is as follows:—

Monday, September 30.—Arrival of the members at Leeds. Secretaries' office open at the Hall of the Philosophical and Literary Society, Park Row, for registration of names and issue of badges and programmes.

Tuesday, October 1.—Welcome by the Lord Mayor of Leeds at the opening meeting in the Hall of the Philosophical and Literary Society. A selection of papers will subsequently be read and discussed. In the afternoon visits will be made to works in Leeds and the immediate neighbourhood, and to places of interest in the vicinity. Alternatively a lecture will be given by Mr. Rutter in the Art Gallery. In the evening a reception will be held by the Lord Mayor and the Lady Mayoress at the Town Hall.

Wednesday, October 2.—Meeting in the morning for the reading and discussion of papers, and in the afternoon visits to works in the neighbourhood will be made. For ladies it is proposed to arrange a whole day's excursion to Fountains Abbey. In the evening the Council of the University will hold a reception in the University buildings.

Thursday, October 3.—Meeting in the morning for the reading and discussion of papers, and in the afternoon the members and their ladies are invited by Lord and Lady Airedale to a garden party at Gledhow Hall. In the evening they will attend a performance at the theatre by invitation of the General Reception Committee.

Friday, October 4.—A visit will be made to North Lincolnshire.

Visit by Newcastle Foundrymen.

On Saturday, July 20, the Newcastle and District Branch of the British Foundrymen's Association paid the first visit of the session, this being to the works of Messrs. Pease & Partners, Cargo Fleet. Some 35 members availed themselves of the firm's kind invitation and a most enjoyable and interesting afternoon was spent. On arrival at the works the party was received by Mr. Fred P. Wilson, general works manager, Messrs. Fairgrieve, Palmer and others. Parties were formed, and the tour round the various shops and departments made. The general jobbing foundry, special machine-work foundry, railway-castings department, also the direct-castings shop, were all inspected in turn. This latter shop was of special interest to the members, and many were the questions to the guides. The engine house, with its latest type of Parson's turbine, was generally admired, many of the members marvelling at the ease with which this type of motor can be adjusted to meet requirements. The acceleration of its speed from 2,500 revolutions per minute to 3,500 almost instantly was particularly interesting.

A visit to the top of the blast-furnaces was also made. A very fine view of the River Tees rewarded those who made the trip. The charging of one of the furnaces was also witnessed. A sigh of relief escaped most of the members when the furnace was closed and the cone in position again. A return to the general offices of the Company was now made, and further hospitality dispensed. A hearty vote of thanks was proposed by the President of the Branch, Mr. Wallis, seconded by Mr. Henderson, and carried unanimously. Mr. Wilson responded for the firm in a kindly and graceful manner. The party then visited the new transporter bridge and the docks, under the guidance of Mr. Fairgrieve. Tea, which was provided at a local hotel, ended the first outing of the Branch, a function which was, in every way, most successful. Another visit has been arranged for South Shields early in September to the works of Messrs. Smith & Company, ironfounders.

"F. T. J." Bookshelf.

The Metallurgy of Cast Iron.

By Thomas D. West. Cleveland, Ohio, U.S.A.: The Penton Publishing Company.

Mr. West has now the satisfaction of seeing his valuable work on "Metallurgy of Cast Iron" appearing in its fourteenth edition. It comprises, it will be remembered by many of our readers, an exposition of the processes involved in the treatment, chemically and physically, of cast iron, from the blast-furnace through the foundry to the testing shop. The ground on which this book most appeals to practical men is that it is compiled by an essentially practical man, and embodies not so much theory culled from eminent authorities as the experience and conclusions of the author himself. There are many minor points at which Mr. West comes into conflict with others, particularly in this country, but the general value of his work cannot be denied. The present edition has undergone considerable revision, and useful information has been added, while certain minor corrections and changes have been made that were deemed desirable. The author comments on the fact that foundry advancement has not yet justified the exclusion from this book of the matter dealing with the fallacy of judging the grade of pig-iron by its fracture. We are not surprised, and, so far as English readers are concerned, we should be sorry to see that matter deleted at the present moment; for considerable progress has yet to be made before grading by fracture can be wholly superseded. Even under American conditions, which are more favourable to the adoption of scientific grading, the old system dies hard. It is unnecessary to detail the contents of a book so well-known, but we may say, for the information of those not yet acquainted with it, that the contents are calculated to be of very great aid to all classes of foundry workers.

DAVID BROWN & SONS (HFD.), LTD., Park Gear Works, Lockwood, Huddersfield.—A high-class illustrated booklet entitled "The Valveless Car Handbook," relating to Dodson motors.

THE BRITISH ALUMINIUM COMPANY, LIMITED, 109, Queen Victoria Street, London, E.C.—Illustrated pamphlets relating to aluminium as applied to gas lamps, ship and cabin fittings, sheet-metal work, and electric conductors for railway service.

Tests of Chillable Irons.*

By Thos. D. West.

Before proceeding with the following original series of tests of chillable irons, it was desired to find what size of bar should be used with different grades of iron to produce a bar of all grey iron and at the same time a companion bar that could be wholly chilled, or of a white iron, both poured from the same basin or ladle. Sets Nos. 1 and 2 show that bars 1⅝ in. in diameter are suitable for various grades of chillable metal having its silicon ranging from 0.90 to 1.20. The balance of the sets show 2¼ in. diameter bars to be suitable for many grades having a range of 0.50 to 0.90 per cent. silicon. It is to be understood that in either of the above the constituents, other than silicon, are generally the same as used in the making of such castings as chilled car wheels and rolls. In some cases the larger bars may be used for higher silicon metal, this depending chiefly upon the metal being high in sulphur and no ferro-manganese being used. While the round bar is advocated for a standard, it is to be understood that there are cases of experimental work such as presented in this Paper, where 1½ in. or over square bars may be advisable; but for ordinary practice to obtain comparisons in mixtures, grades of metal, etc., the round bars are to be preferred.

For moulding the square bars three flasks were constructed, each being adapted to cast three or four bars. These bars were 2 in. square by 24 in. long. For casting the round bars, two chiller moulds having a bore of 1⅝ in., later on bored out to 2 $\frac{5}{16}$ in were used in connection with two pipe sand moulds.

Methods for Obtaining and Alloying Metals to Test their Efficiency.

In casting sets for these tests, the bars were poured with the regular metal from a reservoir ladle under the cupola spout, with a capacity of about 7 tons, and carried to the moulds in a "bull ladle" which held about 250 lbs. Twelve ounces of ferro-manganese was thrown into the ladle, in order to secure the same composition as used for car wheels where 2 to 2½ lbs. of ferro-manganese is added to every 700 or 800 lbs. of metal.

After the bars were poured of this regular wheel metal the bull ladle was again filled as often as needed and vanadium or titanium, or both together, added according to the test to be made, along with the 12 oz. of manganese. The ladle was allowed to stand for three or four minutes to permit the alloys to melt thoroughly and mix with the metal. A ½-in. rod was used to agitate the metal to help bring to its surface any oxides created by the alloys. The two three or more ladles of metal required for a set were taken from the reservoir ladle before any additional tap of metal was run into it from the cupola.

Casting and Chilling the Alloyed Metal.

In pouring either of the above alloyed metals with the regular metal to obtain a set of square bars, a set of round bars would be poured with the same ladle. In casting the square test bars, some had a 2 in. by 2½ in. chiller on two sides, as illustrated at TC in the end view of Fig. 1, so as thoroughly to chill the bar to make it all white iron. Others had a wrought plate ¼ or ½ in. thick as desired, on one side of the bar only, as at PC, in order only partly to chill one side of the bar. Bars to be free of chill were surrounded with sand, as seen at AG. In some cases two totally chilled bars and one all grey bar might be cast in the one flask. Again, two partially chilled, one totally chilled, and one all grey bar might be cast in one flask. This order could be changed in providing for three to four bars being made in a flask.

The character of the chill, or grain of iron, is given in the tables under the heading "Fracture." Should an all-sand moulded bar show a slightly mottled grain in its fracture instead of being all grey, the words

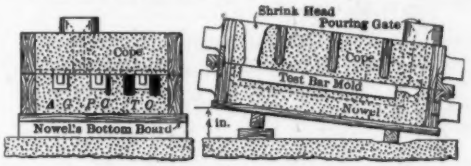


FIG. 1.—SECTIONAL VIEWS OF MOULD FOR MAKING THE SQUARE TEST BARS.

slightly mottled are inserted. Should the fracture be strongly mottled the notation is the word "deeply" in the place of "strongly." In cases where the depth of a partly chilled bar was measured the thickness of the chill is given in connection with the statement that one side was chilled.

TABLE 1.—*Analysis of Sets Alloyed with Vanadium and Titanium.*

Set No	Oz of Vanadium to 225 Lb of Metal	Oz of Titanium to 225 Lb. of Metal	Per Cent of Vanadium in Test Bars	Per Cent of Titanium in Test Bars	Per Cent of Manganese in Test Bars
9	.0	..	0.06	...	0 63
11	..	10	...	0 02	0 72
13	22	..	0 12	..	0 64
15	..	22	...	0 07	0 60
18	5	10	0 04	0 03	0 69
19	8	15	1 05	0 05	0 68

To indicate that one of the vertically cast sides, also the cope surface, or the nowel (drag) face of a bar is in tension when testing a bar, the words "Nowel," "Cope," and "Side" are placed on the line with the respective bar in the column headed "Tension." This will be better understood by referring to Figs. 2 and 3, where the side and end views

TABLE 2.—*Transverse Tests 1¾ in. Square and 1⅝ in. Round Bars.*

Test No	Fracture	Width	Depth	Tension	Maximum Load	Deflection	Modulus	Set No
1	All white	1 73	1 72	Nowel	5140	0 016	18070	1
2	All white	1 68	1 69	Side	13160	0 038	48380	1
3	Slightly mottled	1 73	1 76	Side	15300	0 060	50820	1
4	All white	1 59	diameter	...	4780	0 023	36280	1
5	Slightly mottled	1 60	diameter	...	7240	0 065	54670	1
6	All white	1 69	1 69	Nowel	7580	0 038	38260	2
7	All white	1 71	1 71	Side	18290	0 042	58010	2
8	Strongly mottled	1 72	1 70	Side	11940	0 038	39000	2
9	All white	1 60	diameter	....	8820	0 032	43350	2
10	Almost white	1 56	diameter	....	8540	0 040	44830	2
11	All white	1 59	diameter	....	3060	0 021	23370	2
12	Strongly mottled	1 58	diameter	...	7700	0 073	60030	2

of the bars are shown in two ways of being tested. In the case of round, as well as square bars that are cast on end, as were Nos. 84 and 88, it makes no difference which way they are placed on the distance supports, Figs. 2 and 3, when being tested.

* Paper presented before the American Society of Mechanical Engineers.

The width and depth as well as the diameter of all the tested bars are given in Tables 2 to 9, to permit a checking of the modulus of rupture column; also present data for other formulæ for computing variations in the size of the bars shown. It is to be understood that the records of all tests given are of solid

FIG. 2.—END AND SIDE VIEW OF A TEST BAR MADE IN MOULD, FIG. 1.
W shows Grey Side in Tension and Strong Position; *E* shows Horizontal Plane of Chill Crystal in Tension and Weak Position.

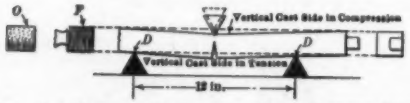


FIG. 3.—SECOND TEST ON A 2-IN. SQUARE BAR.

O shows Chilled Side in Tension and Weak Position; *F* shows Veritcal Plane of Chilled Crystal in Tension and Strong Position.

bars and complete fractures; as should there have been a slight flow in any of those tested it would have been in the compression face of the bar where it could have no effect in reducing its strength.

Transverse Testing and Practicability of Drop Tests.

All transverse tests on both round and square bars, Tables 4 to 8, except tests 59 and 77, were made with a 12-in. span, as seen in Figs. 2 and 3. Tests 59 and 77 were made with a 10-in. span. All drop tests of Tables 4 to 8 were made with a 12-in. span and all drop tests for Table 9 were made with an 8-in. span.

The drop tests were made with a 25-lb. weight having the first drop at a height of 6 in. and raised 6 in. higher for every blow until breaking the bar. If, for example, 6 is the number in the drop column of the tables, it means that the weight dropped once at each of the respective heights, 6 in., 12 in., 18 in., 24 in., 30 in., and 36 in., before breaking the bar.

TABLE 3.—*Transverse Tests of Variable Depths of Chill with Low Chilling Iron.*

Test No	Fracture and Per Cent of Chill	Width	Depth	Load	Deflection	Modulus	Set No
13	Not chilled; clear gray iron	1 01	1 51	3815	0 066	42900	4
14	Chilled one side: 10% white	1 00	1 50	4350	0 055	34600	4
15	Chilled two sides: 25% white	0 98	1 44	3270	0 058	29600	4
16	Not chilled; clear gray iron	0 98	1 48	3175	0 105	44200	5
17	Chilled one side: 15% white	1 03	1 48	4230	0 089	33700	5
18	Chilled two sides. 20% white	1 02	1 45	4280	0 070	36900	5
19	Not chilled; clear gray iron	0 97	1 47	5000	0 103	43000	6
20	Chilled one side; 1% white	1 00	1 47	5610	0 108	46750	6
21	Chilled two sides: 100% white	1 01	1 47	6400	0 080	52600	6
22	Not chilled, clear gray iron	1 00	1 46	4350	0 157	26700	7
23	Chilled one side; 5% white	0 99	1 45	4350	0 139	40200	7
24	Chilled one side; 80% white	1 06	1 50	4300	0 127	31700	7
25	Chilled two sides: 50% white	1 09	1 50	3900	0 110	19300	7

The bars for the drop tests Tables 4 to 8 were obtained by taking the long end of the 24-in. long square bars after they had stood one transverse test. This is why two kinds of tests with the same bar are given under the same test number.

A comparison of the drop tests with the transverse tests shows that where a bar is strong transversely it generally shows a relatively high strength under the drop test. This was also true in the case of nearly all of the round bars having a 6-in. span, but these tests are not given herein.

For castings that are subject to shock or sudden impact, such as car wheels, rolls, shears, dies, etc., the drop test should grow in favour. The apparatus costs little and the time required is less than that needed in any other method of testing.

Treatment and Analysis of Regular Car Wheel and Alloyed Metals.

No special complete analysis is given of the respective sets, beyond stating that the range of chemical analysis for chilled car wheels is as follows:—Silicon, 0.55 to 0.65 per cent.; sulphur, 0.100 to 0.150 per cent.; manganese, 0.55 to 0.70 per cent.; phosphorus, 0.270 to 0.320 per cent.; combined carbon, 0.60 to 0.70 per cent.; graphitic carbon, 2.70 to

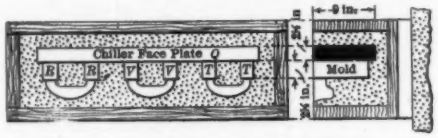


FIG. 4.—OPEN-SAND MOULD FOR MAKING COMPARATIVE CHILLING TESTS.

2.90 per cent. This is owing to the fact that car-wheel mixtures or analyses, from one foundry at least, vary but little. Table 1 gives the vanadium and titanium constituents of the test bars. Analyses of metal taken directly from the reservoir ladle before the ferro-manganese was added showed this metal to contain around 0.40 manganese. The drillings for

TABLE 4.—*Bars 26 to 30 had 12 oz. Manganese; 31 to 34, 12 oz. Manganese and 10 oz. Vanadium in 225 lbs. of Metal.*

Test No	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No
R 26	Chilled both sides. All white iron	2 04	2 00	nowel	18150	0 080	33420	4	8
R 27	Chilled ½ in. one side	2 10	2 05	nowel	14330	0 086	29230	6	8
R 28	All gray iron	2 12	2 08	nowel	23860	0 070	46830	9	8
R 29	All gray iron	2 31	diameter	....	25750	0 095	63710	..	8
R 30	Chilled. All white iron	2 21	diameter	....	14820	0 080	41330	..	8
V 31	Chilled two sides. All white iron	2 08	1 97	nowel	16100	0 080	35800	4	9
V 32	Chilled ½ in. one side	2 05	1 99	nowel	15370	0 035	34080	5	9
V 33	All gray iron	2 08	2 00	nowel	22020	0 070	47640	9	9
V 34	All gray iron	2 32	diameter	....	23430	0 070	57300	..	9

Set R poured with regular iron Set V poured with vanadium in regular iron Set T poured with titanium in regular iron

regular car-wheel metal analyses are taken from blocks about 2 in. by 2½ in. by 8 in., cast in all sand so as to leave a grey body in the metal, which will agree closely with the grey between the plate and body back of the chill of a car wheel.

Sensitive Conditions in Testing Chillable Irons.

Table 2 shows that bars 1¾ in. square and 1⅝ in. round are too small for regular car-wheel metal. This is seen by the all-sand bars 3, 5, 8, 10 and 12, showing a fracture a little too strongly mottled instead of a fair grey structure. These sizes of bars are recommended only for chillable irons ranging from 0.90 to 1.20 per cent. in silicon for use in general practice.

The foregoing is a general statement requiring modifications in some instances. A comparison of the strength of bars 4, 5, 11 and 12 with 9 and 10 shows the cases in which strongly mottled iron of the same metal, also iron tending to all white, as No. 10, will give exceptional strength. Many other round bars 1⅝ in. in diameter were made, but broken with the sledge to check these fractures. The two odd bars 11 and 12 are shown chiefly to demonstrate the distinction they display.

When a bar is of such a size that it is sensitive to assume a mottled form, it is very likely to go further and become almost white, and with the same iron, temperature of metal and character of mould, there is as much chance of obtaining a strength of 7,760 lbs. as 5,540 lbs., as seen for bars 10 and 12. But this sensitive condition must be avoided in order better to make comparisons between an all-chilled bar and an all-sand cast one of the same size, form, and metal. To do this, it is necessary to have the sand-cast bars sufficiently large to prevent their taking a mottled form, and still not so large as to prevent their being absolutely chilled, or all white iron to their very centre, when cast in an all-iron mould or chiller of the same diameter. Much experimenting may often be necessary to learn to know the best size to adopt for making a comparison between the white and grey of special chillable irons. It will be seen by the Tables having the 2¼-in. round bars, that even with this increase over the 1⅝ in. in diameter, some of the larger bars show a slightly mottled fracture with the silicon around 0.60. This could have been largely avoided by baking or drying the sand moulds, as those used in the tests shown were all of green sand. To increase the size of the round bar would assist this feature, and such could be done to the extent of having it 2¾ in., and possibly 3 in. in diameter, and still produce a perfect, all-chilled bar for a companion to an all-sand cast or grey one having the silicon around 0.60.

It is important, therefore, to describe the structure of fractures when recording tests of chillable iron and in making comparisons with all-chilled and grey bars or otherwise. It all shows that in some cases it may be necessary to experiment in order to obtain the diameter best suited to give a knowledge of the relative strength of the white and grey of chillable irons. This does not prevent the adoption of a standard to be used the world over for tests for chillable irons. All that is necessary is to state the structure of the fracture, diameter of the bar used, per cent. of silicon, and possibly other constituents, should they vary much from those quoted earlier.

Erratic Effects of Chilled Crystals and Interlacing of the Mottled and Grey with them.

Table 3 presents a few of the many tests made with chillable metal, having about the following composition: Silicon 2.0, sulphur 0.06, phosphorus 0.04, manganese 0.30. The bars were made in a converter steel foundry. In testing this set, the load was applied in the deep direction of the bars which were all cast on end. Tests 13 to 25 illustrate the erratic qualities of partly chilled bodies, accounted for by the interlacing of the white with the grey and the depth of mottled iron back of the chilled body, all causing more or less internal strain that can often be greatly removed by annealing.

In partly chilled sections, the temperature of the chiller to chill the iron, and of the metal to pour the mould, and the degree of dampness in the sand, have an effect both on the depth of chill, and on the structure of the metal for a considerable distance beyond the place where the white ceases. These are all factors difficult to control in regular practice, but the more that is known concerning them, the better will be the design, make and use of the cast. The variable hardness of mottled and grey bodies, interlacing with the white iron of chilled bodies, are displayed by the hardness tests, Table 11.

Transverse and Drop Tests of Grey and Chilled Bars Alloyed with Vanadium and Titanium.

Tables 4 to 8 present an original series of tests comprising the following features:—

(*a*) Comparison of strength, deflection, chill and contraction, in all-chilled, partly-chilled, and grey bars of the same metal.

(*b*) Comparison of square and round bars to emphasise the utility of the latter for a standard.

(*c*) Comparisons of transverse and drop tests to show their conformity, and practicability of the latter.

(*d*) Comparisons of hardness created by the rate in cooling, giving chilled, mottled and grey fractures in the same metal.

(*e*) Effects of ferro-manganese, vanadium, and titanium in the same metal and size of section, when of a chilled, mottled and grey structure.

Results of the above comparisons in connection with those to be derived from a study of the tables are given throughout the Paper.

FIG. 5.—SET OF ALL-CHILLED, PARTLY-CHILLED AND ALL-SAND SQUARE BARS CAST FLAT.

FIG. 6.—SET OF ALL-CHILLED, PARTLY-CHILLED AND ALL-SAND SQUARE BARS CAST ON END.

Difference in the Strength of the Chilled and Grey Sides of a Partly Chilled Casting.

It will be seen from tests in Table 9 that when the chilled face is in extension, as with Tests 92, 94 and 96, the casting is much weaker than when the grey or mottled body is in extension, as with Tests 91, 93 and 95 of Set 22. This is a quality having heretofore received very little, if any, thought. When fully considered it will be seen to be of great importance in the making and use of different lines of castings. The reliability of this set of tests will be realised when it is understood that the respective companion tests having the chilled side in compression and tension were made with the same bar, by the method shown in Figs. 2 and 3. After making two transverse tests of the same bar, there was sufficient remaining for a drop test having an 8-in. span. A few of these are Tests 83 to 96. Bars 83 to 90 were cast on end, while bars 91 to 96 were cast flat, as shown in Fig. 1, and chilled on one side only to give two of this form for one set. In Fig. 6 is seen a full set of the square bars cast on end, in which M is the all-chilled bar, N the chilled side, and O the grey side of the partly chilled bars, while P is the all-sand cast bar. The position of the chilled face in the testing is shown at W for both the cast on end and cast flat bars when upward, and at O when downward, seen on the left of Figs. 2 and 3.

Another feature is the great difference between the strength of chilled iron when the lines of crystallisation stand vertical to the load, and when they are turned horizontal to it. In Table 2, Tests 1, 2, 6 and 7 show a difference of about 61 per cent. for the first two bars, and about 51 per cent. for the second

two. The lines of crystallisation are seen in Figs. 2 and 3, where E is the weakest and F the strongest position of the two-sided bar. These qualities were originally discovered by Asa W. Whitney, and are presented here to give data in keeping with the original tests of this Paper.

Chilling Effects of Vanadium and Titanium.

Information of the chilling qualities of these alloys is given in the various tests of Tables 4 to 8, as Tests 27 and 32. It required but a few tests to show that the difference in the pouring temperature of the metals, due to the cooling effect produced in melting the alloys, was such as to make the depth of the chill shown in Tables 4 to 8 an uncertain factor for these tests. This is more fully realised when the fact is considered that "hot" metal will chill deeper than "dull" metal.

To obtain more favourable conditions for rapid pouring and less travel of metal than was offered by the mould, Fig. 1, cupola chill blocks were made after

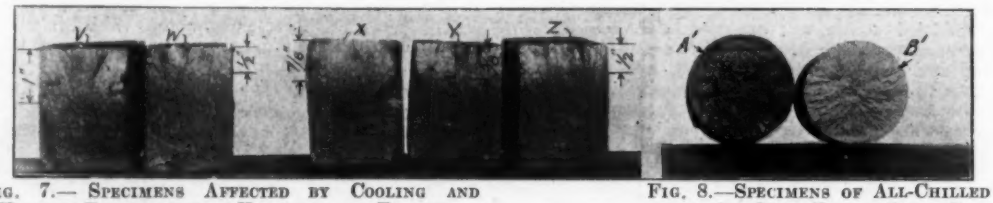


FIG. 7.— SPECIMENS AFFECTED BY COOLING AND VARYING PERCENTAGES OF VANADIUM AND TITANIUM.

FIG. 8.—SPECIMENS OF ALL-CHILLED AND ALL-SAND ROUND BARS CAST ON END.

the plain and end views in Fig. 4. The pair of chilled blocks R were poured with the regular car-wheel metal, cooled down to nearly the same temperature as that for pouring the chill-block moulds V and T having the vanadium and titanium alloys in their respective ladles. This method emphatically demonstrated that the vanadium increased the depth of chill, or held the carbon more in its combined form, while the titanium operated in the opposite direction. Numerous tests were made following this plan, some of which had a ½-in. chiller face plate in place of the 2½-in. plate Q, and all of them were effective in the same direction as to their respective results.

One test with the three sets of moulds, Fig. 4, gave a difference in the thickness of chill as seen at

TABLE 5.—*Bars* 33 *to* 39 *had* 12 *oz. Manganese; Bars* 40 *to* 44, 12 *oz. Manganese and* 10 *oz. Titanium in* 225*lbs. of Metal.*

Test No	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No
R 35	Chilled both sides. All white	2 14	1 98	nowel	22420	.....	66108	..	10
R 36	Chilled ⅛ in one side	2 08	2 07	nowel	18090	0 037	39170	3	10
R 37	All gray iron	2 13	2 04	nowel	25740	0 075	54700	11	10
R 38	All gray iron	2 27	diameter	....	25520	0 077	66570	..	10
R 39	Chilled. All white iron	2 22	diameter	.....	13440	0 024	37477	..	10
T 40	Chilled both sides. All white	2 02	1 97	nowel	16100	0 031	36960	4	11
T 41	Chilled ⅛ in. one side	2 07	2 00	nowel	15130	0 032	33280	5	11
T 42	All gray iron	2 08	1 99	nowel	21870	0 074	48350	9	11
T 43	All gray iron	2 32	diameter	....	23400	0 069	57180	..	11
T 44	Chilled. All white iron	2 29	diameter	...	17110	0 038	47711	..	11

X, Y and Z, Fig. 7. The Set R was poured with the regular iron; the Set V with the vanadium, and the Set T with the titanium alloyed metal, there being 1 lb. of each alloy in about 175 lbs. of metal.

Further experiments having 2 lbs. of titanium in the 175 lbs. of metal gave a thickness of chill seen at V and W, Fig. 7, of 1 in. in the regular metal and ½ in. in the alloyed metal respectively, as marked in the illustrations. In the belief that by increasing the amount of titanium the chill might be wholly prevented, 4 lbs. was put into the metal for two tests. This did not act as effectively as the 2 lbs. and showed that by its use iron could not be prevented from chilling beyond a certain limit.

Effects of Vanadium, Titanium and Other Factors on Contraction.

Tests to obtain contraction were made with both round and square bars and are given in Table 10. The 2¼-in. round bars show the contraction for a length of 12 in. and the square bars for 22 in. The ratios for contraction of the bars cast on end agree closely with those of the bars cast flat. The regular irons are fairly uniform in their contraction. The vanadium bars show a greater contraction than those containing titanium, the latter having the least of any of the metals. The spurious metal of Set 16 having no ferro-manganese in it, shows the greatest contraction. The most radical difference exists between the all-chilled and all-grey bars.

Effects of Vanadium and Titanium on Strength.

In making deductions of the relative strength for the alloy mixtures, etc., the round bars were selected chiefly on account of their uniform structure and greater uniformity of results. Fig. 8 is a good illustration of the uniformity of the metal as it comes in round bars rather than in square ones. The grey round bar A¹ shows a much better uniformity of grain structure than exists in the square bars L and P, Figs. 5 and 6. These last present irregular patches of grains embodying every structure from white at the corners D¹ interlaced with mottled, leading to a grey centre sensitive to change with the least variation in the dampness or character of the sand, hardness in ramming, and temperature of pouring metal.

TABLE 6.—*Bars* 45 *to* 49 *had* 12 *oz. Manganese; Bars* 50 *to* 54, 12 *oz. Manganese and* 22 *oz. Vanadium in* 225 *lbs. of Metal.*

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No
R 45	Chilled both sides. All white	1 90	2 03	nowel.	16460	0 030	38230	5	12
R 46	Chilled ⅛ in. one side	2 10	2 00	nowel	14380	0 035	30810	7	12
R 47	All gray iron	2 08	2 01	nowel	25790	0 060	50960	11	12
R 48	All gray iron	2 29	diameter	....	23910	0 078	60730	..	12
49	Chilled. All white iron	2 22	diameter	....	15810	0 022	43530	..	12
V 50	Chilled both sides. All white	2 00	1 98	nowel.	16030	0 035	36800	4	13
V 51	Chilled ⅛ in one side	2 10	2 02	nowel	14090	0 030	29600	3	13
V 52	Gray slightly mottled	2 05	2 00	nowel	24800	0 065	54440	7	13
V 53	Gray slightly mottled	2,27	diameter	....	25580	0 060	66710	..	13
V 54	Chilled. All white iron	2 20	diameter	....	17890	0 025	51250	..	13

This irregularity of structure is likewise apparent in the all-white square bars H and M, Figs. 5 and 6, when compared to that seen at B¹, Fig. 8.

The titanium bars show an increase of strength over the regular bars of 27 per cent. in the white iron with bars 39 and 44, Table 5, and 32 per cent. in the white iron with bars 59 and 64, Table 7. The vanadium bar shows an increase of strength of 9 per cent. in the grey iron, with bars 48 and 53, and 17 per cent. in the white with bars 49 and 54, both of

Table 6. The spurious bars which have no ferro-manganese or other alloys in them, show a decrease of strength of 7 per cent. in the grey iron, with bars 63 and 68 of Table 7. No comparison of the white iron in the round bars can be given, since there are no chilled round bars for this last set; but the contrast is so great in the square chilled bars 55 and 65, which show the white of the spurious metal, that it is safe to consider them 30 per cent. weaker than the regular iron.

Some tests having shown vanadium and titanium beneficial in increasing the strength, it seems reasonable to suppose that all the other sets having them

TABLE 7.—*Bars 55 to 59 had 12 oz. Manganese; Bars 60 to 64, 12 oz. Manganese and 22 oz. Titanium in 225 lbs. of Metal, while Bars 65 to 68 were free from Manganese and other Alloys.*

Test No	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No
S 55	Chilled both sides. All white	2 00	2 00	nowel	15980	0 030	33980	4	14
S 56	Chilled ½ in. one side. Balance mottled	2 00	2 07	nowel	18140	0 035	38100	4	14
S 57	Gray iron - Corners chilled	2 02	2 00	nowel	22730	0 070	50610	7	14
S 58	Gray iron, slightly mottled	2 25	diameter	....	26000	0 075	69640	..	14
59	Chilled All white	2 24	dianeter	....	13830	0 017	32966	..	14
T 60	Chilled both sides. All white	2 00	1 95	nowel	13200	0 025	30300	4	16
T 61	Chilled ½ in. one side Balance mottled	2 04	2 05	nowel	16840	0 035	36060	4	15
T 62	Gray, corners slightly chilled	2 05	2 00	nowel	23080	0 075	48470	10	15
T 63	Gray iron	2 25	diameter	....	25810	0 08	68230	..	15
T 64	Chilled All white iron	2 22	...	...	18070	0 05	44810	..	15
S 65	Chilled both sides All white	2 04	2 04	nowel	11400	0 020	24170	3	18
S 66	Chilled ½ in one side Deeply mottled	2 05	2 04	nowel	10980	0 030	22900	3	16
S 67	Gray, corners mottled	2 04	2 00	nowel	17870	0 040	39420	5	16
S 68	Gray iron, mottled	2 25	diameter	....	24180	0 055	64204	..	16

Set S poured with spurious metal containing no ferro-manganese

alloyed in the regular metal should show a similar tendency. It may be that in car-wheel metal there is a definite absorption of the alloys necessary to increase materially the strength of the grey and white. By the use of large round test bars for making the relative comparison in these irons, further experimenting with this grade of metal along practical lines should establish beyond any doubt the question of such a limit.

Comparison of Partly Chilled with Wholly Chilled and Grey Bodies.

In conducting this series of tests, bars were cast

TABLE 8.—*Bars 69 to 72 had 12 oz. Manganese; Bars 73 to 77, 10 oz. Titanium and 5 oz. Vanadium; Bars 78 to 82, 12 oz. Manganese, 15 oz. Titanium and 8 oz. Vanadium in 225 lbs. of Metal.*

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No
S 69	Chilled both sides. All white	1 98	2 02	nowel	18480	0 035	41170	5	17
S 70	Chilled ½ in. one side. Balance mottled	2 04	2 80	nowel	16760	0 055	23660	6	17
S 71	All gray iron	2 05	2.05	nowel	24390	0 065	51020	11	17
S 72	All gray iron	2 27	diameter	....	24080	0 065	62660	..	17
T 73	Chilled both sides. All white	2 03	2 00	nowel	12330	0 035	27470	..	19
T 74	Chilled ½ in. one side. Balance mottled	2 05	2 07	nowel	18340	0 040	37560	6	19
T 75	All gray iron	2 10	2 04	nowel	24980	0 065	51290	11	19
T 76	All gray iron	2 29	diameter	....	23070	0. 060	58060	..	19
T 77	Chilled All white iron	2 21	diameter	....	16370	0 029	38560	..	19
T 78	Chilled both sides. All white	1 98	2 03	nowel	16350	0 030	36210	4	19
T 79	Chilled ¼ in. one side Balance mottled	2 00	2 04	nowel	14580	0 040	31530	5	19
T 80	All gray iron	2 04	2.00	nowel	22240	0 065	49060	8	19
T 81	All gray iron	2 29	diameter	....	23470	0 060	59620	..	19
T 82	Chilled. All white iron	2 20	diameter	....	18700	0 030	53570	..	19

having only one side chilled, as companion bars to the all-chilled and grey bars, as seen by the second test, Tables 4 to 8. It will be a surprise to many to find that in all the tests, excepting the two of Set 14, the partly chilled bars are weaker than the all-chilled or white bars. A good view of these three companion bars is shown in Fig. 5, K being the partly chilled side.

The weakness of the partly chilled bars is due to internal strains and scattered amalgamation of the state of the broken carbon of the metals. Bars showing nearly every effect of rapid and slow cooling, and in no wise possessing the homogeneous blending of one character of grains, seen by the wholly white and grey, are well illustrated by H, I, Fig. 5.

All the partly chilled bars showed the chilled body interlacing the mottled and the latter blending into the grey, Figs. 5, 6, and 7. This is generally considered to be a stronger section than those where a distinct line marks the separation of the white and grey, and causes conditions such as can still further increase the weakness of partly chilled castings. Designers should duly consider this factor; so as either to have a strong backing of the mottled and the grey, or to have the chilled side of the casting arranged in compression if practical, when strains or

TABLE 9.—*Transverse and Drop Tests of one side Chilled Bars Alternated to be in Compression and Tension.*

Test No.	Fracture and Per Cent of Chill	Width	Depth	Load	Deflection	Modulus	Drop	Set No
83	Gray iron, slightly mottled	2 00	2 08	31070	0 045	42760	7	20
84	Chilled four sides. All white	2 12	2 15	23280	0 040	41770	15	20
85	Chilled ½ in. one side Balance mottled Gray side in tension	2 06	2 05	21590	0 030	43435	9	20
86	Chilled ⅜ in. one side. Balance mottled Chilled side in tension	2 07	2 03	20430	0 035	43111	7	20
87	Gray iron, slightly mottled	2 11	2 07	19430	0 043	38664	4	21
88	Chilled four sides. All white	2 06	2 20	23480	0 030	40532	15	21
89	Chilled ⅜ in. one side. Balance mottled Gray side in tension	2 10	2 04	19280	0 030	40947	8	21
90	Chilled ⅜ in. one side Balance mottled. Chilled side in tension	2 06	2 06	13860	0 020	28132	6	21
91	Chilled ¼ in. one side, ¼ in mottled Gray side in tension	2 11	2 15	23760	0 070	43881	14	22
92	Chilled ¼ in. one side, ¼ in mottled. Chilled side in tension	2 13	2 06	17260	0 035	34373		22
93	Chilled ¼ in. one side ¼ in mottled Gray side in tension	2 12	2 10	21760	0 055	41914	7	22
94	Chilled ¼ in. one side, ¼ in. mottled Chilled side in tension	2 13	2 06	13160	0 035	26378		22
95	Chilled ½ in one side; 1 in. mottled Gray side in tension.	2 11	2 03	20550	0 055	42127	4	22
96	Chilled ½ in one side; 1 in. mottled. Chilled side in tension	2 13	2 13	15730	0 030	29981		22

concussions of its work are brought to bear upon it, a feature in keeping with the tests on treatment of Table 9.

Comparison of Strength in All-White and All-Grey Irons.

A feature worthy of consideration is the strength and deflection obtainable in strictly all-chilled or white iron. It is generally supposed that white iron is very much weaker than grey, and has very little if any deflection. By referring to Tests 7, 21, 30, 35, 44, 49, 54, 69, 82, 84 and 88, it will be seen that white iron can be obtained at least 75 per cent. as strong as grey. White iron is the strongest with the crystals radiating from a centre as at M and B¹ Figs. 6 and 8. The round bar excels the square in this form of structure. The chief evil of white iron lies in its strength being erratic, and easily spalled. It is believed that founders could greatly increase and control the strength of various grades of white irons and make them much more reliable.

Numerous experiments were conducted to test the spalling weakness of white and grey iron and it was found that white bodies do not possess much over one-third the strength to resist spalling blows that exists in the gray or mottled of the same iron. It shows the importance of designing that portion of the casting subject to such blows to contain as far as practical grey or mottled iron.

Hardness Tests of All-Chilled, Partly-Chilled and Sand-Cast Test Bars.

Table 11 gives Brinell and Scleroscope tests of three samples taken from each of the first three bars of Sets 12 to 19, a view of which is seen in Fig. 5. The Brinell depressions were produced by a $\frac{3}{8}$-in. ball loaded with 6,000 lbs. and the readings are the weight in kg. sustained by 1 mm. of area of the depression produced by the total load. This is the standard method of testing Brinell hardness. Both the Brinell and Scleroscope records are the averages of 4 to 6 tests on a sample.

The columns H, I, J, K and L gives the tests of the surfaces indicated by the same letters shown in Fig. 5. Those who conduct these kind of tests know that there is some variation of hardness over an area, although it may not exceed 1 sq. in.

TABLE 10.—*Contraction of Round Bars Cast on end and Square Cast Flat.*

Set No	Round Bars. All Chilled	Round Bars. All Grey	Square Bars. All Chilled	Square Bars. Part Chilled	Square Bars. All Grey
S 12	0 23	0 12	0 47	0 38	0 26
T 13	0 23	0 13	0 48	0 30	0 27
S 14	0 23	0 12	0 47	0 28	0 26
T 15	0 21	0 11	0 43	0 29	0 25
S 16	...	...	0 50	0 30	0 25
S 17	...	...	0 49	0 31	0 28
TT 18	0 23	0 13	0 47	0 29	0 26
TT 19	0 23	0 13	0 48	0 30	0 27

The surfaces H had a variation of 3 to 7 points and I, 8 to 15 points, J about 6 points, while L had but 3 points, showing that a greater uniformity in hardness can be expected in all-grey bodies than in mottled or chilled surfaces.

The table also shows that directly-chilled faces, as H, are harder than those crystallising over a sand surface caused by the heat-absorbing effect of a chiller, some distance from such points, as I. The excessive variation of the surface I is believed to be caused by the curved structure of the heat radiation lines, as they come to the surface at an angle, differing from the straight lines shown on the sides at H.

The spurious iron is on an average harder than the regular iron. The alloys appear to have a hardening effect as compared with the regular iron, or that having only ferro-manganese in it. The irregularity in the effect of the alloy is no doubt due to the variations in the temperature of the metal filling the moulds, and brings about variations in hardness similar to creating an irregularity in the chill, strength, deflection and contraction of like irons.

Nearly all the bars tested for records in this paper were cast at the Cleveland plant of the National Car-Wheel Company, and tested by Mr. H. E. Smith, engineer of tests, assisted by Mr. G. E. Doke, both of the Lake Shore and Michigan Southern Railroad,

TABLE 11.—*Brinell and Scleroscope Hardness Tests of of Specimens, Fig.* 4.

Set No.	Class	H		I		J		K		L	
		Brl.	Sel.	Brl	Sel	Brl	Sel	Brl.	Sel.	Brl	Sel
12	S	331	45	248	39	179	29	326	55	185	30
13	T	277	53	236	50	227	41	405	80	190	41
14	S	417	66	402	58	185	35	396	61	175	36
15	T	429	58	437	56	211	41	419	58	186	40
16	S	403	59	413	59	224	40	443	60	191	42
17	S	358	53	390	56	199	39	317	47	175	37
18	TT	363	64	373	61	193	40	400	54	183	40
19	TT	443	66	422	64	189	41	417	57	179	38

Collinwood, Ohio. Assistance was rendered in making the bars by Messrs. H. E. McClumpha, general manager; J. D. Cunningham, plant manager; and Charles K. Logue, foreman of the wheel found. Some of the tests shown herein were made by Prof. John H. Nelson, of the Case School of Applied Science. The hardness tests were made by Mr. Robt. R. Abbott, metallurgical engineer of the Peerless Motor-Car Company; the analyses by Messrs. Crowell and Murray, chemists, both firms of Cleveland. The vanadium was furnished by Mr. George L. Norris, engineer of tests of the Vanadium Sales Company of America, and the titanium by Mr. Charles V. Slocum, general sales agent of the Titanium Alloy Manufacturing Company, both of Pittsburgh, Pa. All the test bars were made by the writer and tested under his supervision, who hereby desires to tender sincere thanks to all above firms and gentlemen for having so kindly and ably assisted him in these researches.

Unemployment Insurance Contributions.

A circular has been issued by the Board of Trade in which they point out that as some misapprehension appears to exist on the matter, they wish to make is known that no stamps can be used for payment of contributions in respect of Unemployment Insurance other than the special Unemployment Insurance Stamps, which are obtainable at any post office. Health Insurance Stamps and ordinary postage stamps cannot be used for the purpose and, if affixed, do not count as contributions in respect of Unemployment Insurance. Where such other stamps have been affixed, it will still be necessary for the proper Unemployment Insurance Stamps to be affixed, and the liability for affixing them rests upon the employer. For the present, however, as a temporary arrangement and with a view to facilitating the correction of mistakes, the Board of Trade will themselves be prepared, without charge, to affix Unemployment Insurance Stamps in lieu of the Health Insurance Stamps wrongly affixed; obtaining the employer's acknowledgment. For this purpose all unemployment books to which a Health Insurance Stamp or stamps have been wrongly affixed should, as soon as possible, be sent to a Divisional Office, with a request for the affixing of Unemployment Insurance Stamps of value corresponding to the Health Insurance Stamp upon them. The addresses of the Divisional Offices are as follows:—London and South-Eastern, Caxton House, Westminster, S.W.; South-Western, Canada House, Baldwin Street, Bristol; West Midland, 164, Corporation Street, Birmingham; Yorkshire and East Midlands, 14, Frenchgate, Doncaster; North-Western, Lancashire and Cheshire, Cairo Street, Warrington; Wales, Law Courts, Cathays Park, Cardiff; Scotland and Northern, Bath Street, Glasgow; Ireland, 21, Parliament Street, Dublin.

Operation of Patents Act.

MR. BUXTON (President of the Board of Trade), replying to Sir Croydon Marks, writes:—"Since the 28th August, 1908, when Section 27 of the Patents and Designs Act, 1907, came into operation, up to the end of June, 1912, there have been 83 applications for the revocation of patents on the ground that the patented articles or processes have been exclusively or mainly manufactured or carried on outside the United Kingdom. In 20 of these cases the patents have been revoked. Section 24 of the Act, which deals with compulsory licenses, came into operation on January 1, 1908, and from that date up to the end of June, 1912, one petition had been presented for the grant of a compulsory license. This petition was subsequently withdrawn, an arrangement having been made between the parties."

THE engineering works formerly carried on by Messrs. J. Musgrave & Sons, at Bolton, were offered for sale by auction on July 2, but were withdrawn, the auctioneers failing to get a start at £50,000.

Foundry Plant and Equipment.

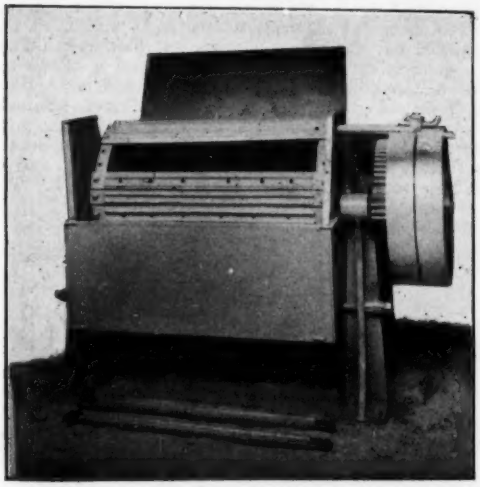
A New Type of Water Tumbling Barrel.

The subject of the annexed illustration, of which the manufacturers are Messrs. James Evans & Company, Blackfriars, Manchester, requires little verbal description. The apparatus consists of an ordinary open rattler mounted in a tank, built of strong galvanised iron sheets. The tank is kept filled with water, so that the lower half of the rattler is always immersed.

This arrangement constitutes a very effective method of cleaning both brass and iron castings. In this machine the most intricate and delicate pieces can be dealt with without injury, owing to the cushioning action of the water.

It has also been found to very effectually remove the sand from the inside of cored work, without having recourse to the use of acid. The achieved results are certainly better than pickling or brushing, whilst the operation is much cheaper.

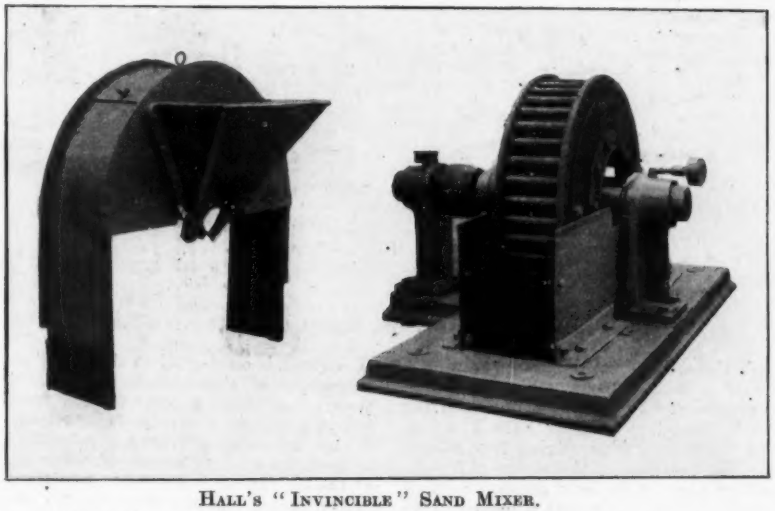
A further economical use for the apparatus which suggests itself is that of dealing with foundry sweepings and trimmings, which might well, in this machine, be made ready for the crucible.



NEW WATER TUMBLING BARREL.

Hall's Invincible Sand Mixer.

An efficient sand mixer being an essential unit of every foundry equipment, the accompanying illustration, showing the "Invincible" sand mixer, of which the sole manufacturers are the Mansfield Engineering Company, Mansfield, will no doubt interest many of our readers.



HALL'S "INVINCIBLE" SAND MIXER.

The illustration is of the 24-in. machine, the capacity of which is from 2 to 3 tons per hour. The speed of the machine is 650 r.p.m., and the required driving power 6 b.h.p. The machine grinds, mixes, screens and toughens the sand at one operation, whilst the toughness and fineness can be altered in a few minutes to suit requirements.

It will be noted that the power consumption is remarkably small for the output capacity of the machine, and this is claimed to be due largely to the patented roller bearing, which is also dust-proof and adjustable. It will be further noted that both the drives are on one side of the machine, thus leaving the other side free for feeding the sand.

The method of fitting up also calls for special mention, as the rings or reels are built up independent of the machine, in such a manner that they can be readily renewed when worn. The pins are not riveted in the plate, but are a driving fit, and are secured by a number of pins which are extended and fitted with lock nuts.

New Blow-Pipe Burners.

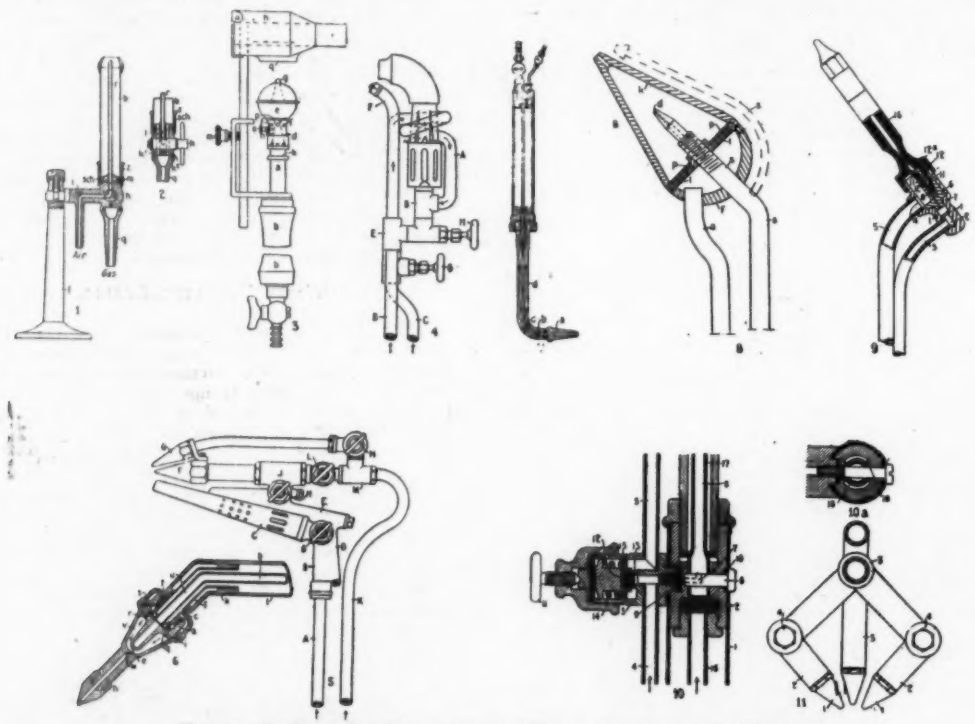
The progress made of late in the process of welding and cutting metals by gas blow-pipe apparatus has opened a new field for the ingenuity of inventors in the design of gas burners specially adapted for use in this connection. Some particulars of recent German developments in this direction have recently appeared,* from which we abstract the following.

The sectional sketches numbered 1 and 2 in the annexed cut show the Jurgens gas blower, which is a combination of a Bunsen burner and a blow-pipe. The blower rotates on the support *f*, and is provided with air and gas ducts *l* and *g*, the air duct *l* connecting with the gas duct when the cock *h* with its angle bore is placed in a suitable position. The gas duct *g* is further divided into two separate ducts k^1 and k^2 leading to the respective plugs of the cock *h*. The gas flows through these ducts into the burner pipe *b* from which either a Bunsen flame or a blow-pipe flame may be produced. In the first case the air admission sleeve is placed so that its holes are just over the holes in the burner pipe, giving free admission to the air. The rotation of the sleeve is accompanied, by means of the pin *m*, by a displacement of the slide valve *sch* opening to the gas a passage into the burner pipe through small holes provided. If the burner is used as a blow-pipe, the sleeve *z* is brought to where it covers the holes in the burner pipe, whereby the slide valve *sch* is placed so that the large openings in it are brought over the ducts k^1 and k^2, and compressed air let in.

No. 3 in the cut shows the soldering acetylene appliance introduced by Tr. Baumann, of Winterlingen, Germany. The gas pipe *a* is provided with a cock and ends in a nozzle *d* enclosed in the shaft of a spherical burner *e*, this shaft being provided with air-admission openings *f*. The nozzle *d* ends in a conical extension *g*, the purpose of which is to produce a narrow flame directed on to the iron *i* surrounded by the jacket *h* with its openings *q*. There is also a spring *n* which can be regulated by the screw *o* so that its tip *p* closes more or less the opening of the nozzle *d*, and thus makes the flame strong or weak, as desired. A wire-gauze screen is provided at *k*, to prevent backfiring.

In burners using liquid fuel, two improvements have been credited to E. Grube, of Altranstädt, Germany. The liquid fuel must, of course, be evaporated before it can mix with the air. The first appliance is shown in No. 4 of the annexed sketches. It comprises a burner with a single superheater coil A from which oil vapour is conducted to the distributing member B, and supplied simultaneously to the injector E and nozzle. The oil vapour formed in the superheater coil A produces a narrow flame at the exit from the nozzle, as in an ordinary blow-pipe, but serves also to feed the welding burner F. For this purpose part of the oil vapour is led aside into the injector E, and mixes there with the oxygen. To start the burner, the superheater coil A, with all valves closed, has to be heated by some outside source of heat. To use the burner for welding purposes, the cock H has to be opened and oxygen admitted to the injector E through the pipe D.

In the second burner by the same designer (see No. 5), the oil, which is led to the burner through the pipe A under pressure, enters into the carburettor B of the blow-pipe E, as well as through a side-duct D into the carburettor E of the welding



VARIOUS DESIGNS OF BURNERS FOR WELDING AND CUTTING METALS.

* "Electro-technischer Anzeiger," and "Transactions" of American Society of Mechanical Engineers.

pipe F. The valves G and H regulate the supply of the oil vapour. The carburettor B is heated by the heat conducted through the metal from the pipe C of the blow-pipe, while the carburettor E is directly surrounded by the flame of the blow-pipe; from E the oil vapour passes into the injector J, and mixes there with the oxygen coming through the pipe K, the flow of the oxygen being regulated by the valve L. A branch pipe M with cock N permits also the regulation of the supply of oxygen flowing under high pressure to the torch O for cutting metals.

To obviate the necessity of having several burners of various sizes for different kinds of work, J. Ammon, of Schöneberg (near Berlin), has designed a burner (No. 6) for welding which may be fitted with different nozzles for different kinds of work. It comprises a nozzle body provided with properly-dimensioned ducts for oxygen and fuel gas, with the nozzle and outer tube in permanent connection. The nozzle body is slipped over the hollow conical nipple *c* connected with the oxygen pipe *b* and combustible gas chamber *l*, the two being connected when necessary by the cap screw *i*. The oxygen flows through the pipe *b* into the duct W and out through the burner nozzle *h*. The fuel gas is drawn by the suction, produced by the flow of oxygen, through the duct *t* into the passage *s*, and thence through the duct *r* into the combustion chamber V. Another burner, on the same principle, but somewhat different in constructive details, has been designed by W. Widmann, of Stuttgart,

The vapour nozzle of the welding burner of the Rheinische Gesellschaft für Autogene Metallbearbeitung m.b.H., of Cologne, Germany (No. 7), consists of several exchangeable parts. The nozzle proper, consisting of three parts, *a*, *b*, and *c*, is screwed to the mixing tube *d*, these three parts being provided with similar threads, so that they may be set at any desired angle to the axis of the mixing tube.

The burner designed by M. Imhoff, of Berlin (No. 8), which may be used both for welding and cutting metals, is constructed so that the oxygen cannot get into the gas pipes. The pear-shaped burner B consists of a semi-spherical base *f* and conical vapour nozzle *k*, divided by the plate *pp* having a large number of small holes *ll* arranged in concentric circles. Acetylene is brought through *a*; oxygen through *s* passing through the base and plate *p*, and provided with the nozzle *d*. The mixture of oxygen and gas flows out through the outer nozzle. When the burner is used for cutting metals, an additional stream of oxygen is supplied through the branch piping s^1. The peculiar shape of the burner permits of cutting a number of holes in the plate *p* so as to allow always a sufficient supply of gas to flow through, with no risk of backfiring. The conical extension *k* is said to favour the mixing of the two gases.

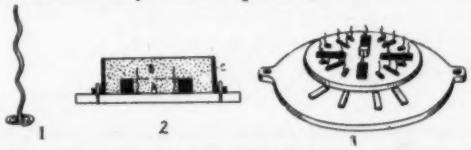
Instead of making provision for exchanging nozzles, the admission of oxygen may be regulated, as is done in the burner of the Apparate-Bau-Anstalt Schmalkalden G.m.b.H., of Schmalkalden, Germany (No. 9). The oxygen pipe 3 opens into the chamber 2, while the acetylene pipe 5 is led to the side opening 4. The headpiece 6 is screwed into the casing 1, and is provided with a central duct, with the front part of 6 eccentrically located, and fitted with cone 11 having in its turn longitudinal grooves 12 opening into ducts 12^a. These ducts are cut in special nozzle-shaped pins connected with cone 11, are of different diameters, and, like the grooves 12, are not limited as to number. Since the path of the oxygen lies through 12^a, enclosed in the cone or pins connected with it, the regulation of the oxygen is not affected by regrinding.

What is claimed to be a new arrangement for distributing the oxygen in burners with a single oxygen pipe is embodied in the burner shown in No. 10, constructed by J. Knappich, of Augsburg, Germany. The oxygen-regulating valve 3, with its admission and discharge piping 4 and 5, is fastened by the screw 6 to the body 2 enclosed in a tube protector 1. The screw passes through the duct 8 for the admission of oxygen for the preheater flame, this duct being closed below the screw, and the screw being provided with a bore 7 connecting the oxygen supply pipes 4 and 8. The inside diameter of 8 is so large that there is always a sufficient area for the passage of the gas, independent of the position of the screw 6. The discs 9 and 10 act as packing. By means of the thumb-screw 11 the valve 3 can be closed or opened, according as the valve cone 12 is pressed against its seat 13, or lifted from it by the spring 14 having as purchase the disc 15. The fuel gas pipes 16 and 17 are tightly fastened to the body 2, the two pipes being connected by the ducts 18 (see 10a). When valve 3 is open, the oxygen brought by pipe 4 flows into 8 as well as into 5. When the valve is closed, the admission of oxygen into the oxidation pipe 5 is stopped, but the gas continues to flow through 7 into the pipe 8.

In the torch for cutting metals introduced by R. Moritz, of Wasquehal, France (No. 11), the nozzles of the fuel gas supply pipes are on pin joints, thus permitting the regulation of the heated space opposite the oxidation nozzle. Oxygen is supplied by the pipe 5, and fuel gas by the nozzles 1.

A Foundry Expedient.

An article on "A New Interesting Expedient in the Foundry" appears in a recent issue of "Giesserei-Zeitung." The formation of a core in a pattern depends on many things, *e.g.*, quality of the sand, execution and design of the pattern, moulding machine used, etc., and does not always succeed, especially when the height of the core is considerably in excess of its diameter. This applies particularly to the case when lifting-type moulding machines are used. With turnover-type moulding machines the cores can be made easier, because with this type of machine the pattern is lifted out of the mould, and the sand is not disturbed. But even there it happens often that the sand is pressed so hard into the core-box that when the pattern is lifted, the core is torn and carried away with the pattern.



To prevent this the firm, H. C. Klotz, of Hamburg, Germany, patented the mould spiral shown at 1 in the illustration, and made of hard wire, with the upper part in the form of a spiral, and the base wound like a snake. The coils of the spiral of the vertical part must not be too close to one another, to allow the sand to get well in. At 2 is shown how the spiral is applied in setting the mould. The spirals have to be set as close to the edges of the core as possible; if the core is of angular or otherwise irregular form, the spirals have to be set in the angles, or wherever there is danger of the piece breaking off. At 3 is shown how by means of this spiral a face plate can be made without cores. It is stated that in one particular foundry there was a saving of 160 cores per day in the manufacture of this one face plate, due to the use of the mould spiral.

Inventions.

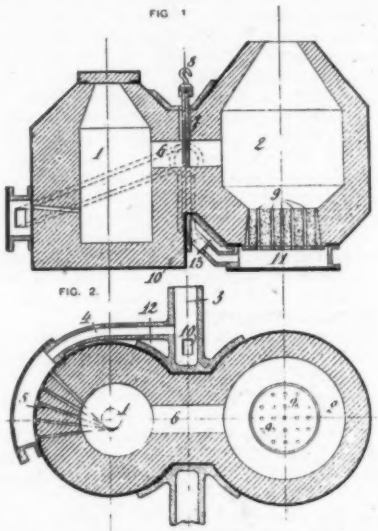
Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

13,055. Extraction of the core keys of pipe moulds P. B. Jagger.
13,189. Making metal pipes and tubes. J. Stewart.
13,282. Process for the manufacture of articles of refractory metals and alloys. P. Schwarzkopf, S. Burgstaller, and Wolfram-Laboratorium.
13,290.*Smelting and brazing with compressed gases. J. Knappich.
13,467. Moulding sand, core sand, and loam mixtures. F. Clapp, L. Sutherland, and V. Varley.
13,470.*Welded joints for steel and iron pipes and tubes. Stewarts & Lloyds, Limited, and J. G. Stewart.
14,164.*Electric-induction furnace. A. Helfenstein
14,234.*Process for casting steel in several layers. (Akt.-Ges. der Brianskor Schienen-Eisenhüttenwerke und Maschinenfabriken, Russia.)
14,711.*Sand-mixing machines for foundries. G. F. Bowdle, J. F. O'Brien, and F. L. Schmidlapp.
14,892. Sand-moulding machines. S. Strettles.
14,953.*Device for tilting the casting-pan of casting-machines. Deutsche Maschinenfabrik Akt.-Ges.
14,972. Treatment or renovation of foundry sand. A. Poulson.
15,252.*Liquid fuel furnaces for melting metals and their alloys and for other metallurgical operations. A. Etienne, L. Cauet, and H. Mercier.
15,283. Furnaces for heating copper ingots. G. B. A. Gibbons and R. Masters.
15,286. Production of metal castings. T. Holcroft & Sons, Limited, and A. Holcroft.
15,628.*Crucibles used in metallurgical furnaces. S. N. Brayshaw and E. R. Brayshaw.
15,638.*Electrically-driven tilling-machines. W. Wortmann.
15,639. Machines for performing cutting and grinding operations of metals. J. Archdale & Company, Limited, and F. Coxon.
15,642.*Machine for ramming in moulding sand. B. Keller.
15,688. Furnaces of the Siemens' reversible regenerative type. A. Reynolds.
15,689. Aluminium alloys. W. N. Naylor and S. P. Hutton.
15,690. Alloys. W. N. Naylor and S. P. Hutton.
15,966.*Metal-hardening method and compound. J. W. Boyd.
16,040.*Induction electric furnaces. J. Bally.
16,041.*Electric retort furnaces. J. Bally.
16,093.*Method of treating metal ingots. G. H. Benjamin.
16,159.*Furnace. E. L. Pamart.

Abstracts of British Patent Specifications recently accepted.

18,016 (1911). *Manufacture of Iron and Steel.* T. Levoz, Givet, France.—Fig. 1 is a vertical section, and Fig. 2 a horizontal section through the axis of the trunnions, the lateral twyers of the first converter and the cylindrical cavity of the second, showing the surface of the bottom, perforated for the passage of the air. The apparatus is, as a whole, a large converter having two converters 1 and 2. The first is lined with silicious materials (silico-alumina bricks), and comprises a lateral set of twyers directed tangentially to a circle of certain diameter, the centre of which is in the axis of the external periphery of converter 1, this direction being favourable for obtaining maximum temperatures by the rational combustion of the combustible elements in the pig-iron. The air blown in is introduced through the trunnions 3 into the conduit 4 and is delivered through the twyers 5 into the converter 1, the latter communicates with converter 2 through a suitable passage 6 lined with silicious material on the side of converter 1 and with basic or neutral material on the side of converter 2. Where the two linings meet there is an opening 7 adapted to receive a damper 8 of refractory material for the purpose of closing passage 6 as may be necessary. The converter 2 is lined with basic material (magnesia or dolomite), and comprises a set of twyers at the bottom. These twyers 9 are of diameter smaller than that generally adopted for the twyers in ordinary Thomas converters; in these latter the twyers have generally a diameter of 10 to 15 millimetres. The twyers in converter 2 have a diameter of 6 millimeters, and are more numerous

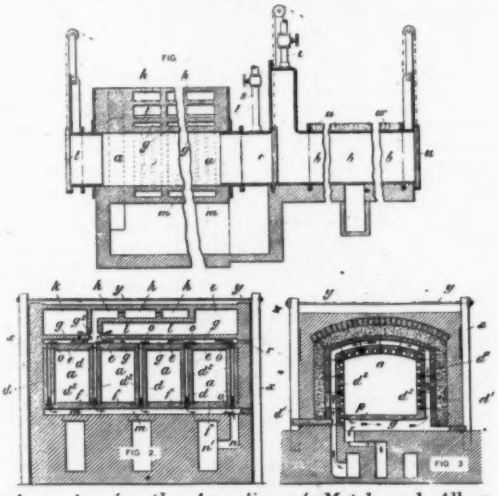


Manufacture of Iron and Steel, by Levoz.

in proportion to the charge treated so as better to distribute the air and to oxidise the phosphorus without burning an excess of iron.. In ducts 4 and 10 are valves 12 and 13, by means of which the admission of air into one or other of the converters may be controlled. The pressure of the air blown in through the lateral twyers may be 40—50 cms. of mercury, and the rate of blow about 60 cb. ms. per minute per ton. In the case of the blow from the bottom the rate may be about 30 cb. ms. per ton per minute, and the pressure may be one atmosphere.

8,362 (1911). *Annealing or Heat Treatment of Metals and Alloys and Apparatus therefor.* T. V. Hughes, 130, Edmund Street, Birmingham.—Figure 1 represents in longitudinal section an annealing furnace constructed according to the invention, portions being broken away; Figure 2 is a cross section of the same, from which it will be seen that the furnace has a series of four parallel muffles; Figure 3 is a cross section through a furnace having a single muffle only. *a, a, a, a* are the muffles of the furnace which may have any length desired, the ends only being represented in Figure 1, and *b* is the chamber provided at one end of the muffles, and preferably in line therewith, in which chamber the articles are submitted to a preliminary heating before passing into the muffle, and in which the articles are gradually cooled after they have been treated for the time necessary or desirable in the muffles *a*, mechanical means of the ordinary kind being preferably employed for effecting the transference of the articles under treatment from the chamber *b* to the muffles *a* and the reverse, and also their introduction into and removal from the chamber *b*. *c* is a non-conducting partition which may be introduced when desired into the opening between the muffles *a*

and the chambers *b* to prevent radiation and splash. The furnace and muffles are built up of fire-clay slabs. Producer gas is supplied to the furnace from a producer, and is admitted to the crossing gas ways *h*. The air is admitted to longitudinal ways or flues *i*, *k*; crossing or side flues *l* passing from the flue *i* to the openings g^2. Holes in the longitudinal flue *k* admit air therein directly to the openings g^2. The air and gas for combustion in the passages *g* are highly heated by the heat of the passages *g*. By the draught of the furnace the heated air and products of combustion pass through vertical passages d^2 in the slabs *d* to the crossing flues *m* under the muffles and by the passage *n* to the waste flue n^1 in connection with a stack. Each flue d^2 and the passage *n* is provided with an independent damper *o* in the form of a movable firebrick, so that any one or more of the vertical flues can be throttled and a practically perfect control over the heating of any one or all of the muffles obtained. The movable fire-bricks or dampers *o* are manipulated by rods inserted through side holes *r*.



Apparatus for the Annealing of Metals and Alloys.

The whole furnace is eventually regulated by a main damper in the stack or in the main flue. The two ends of the apparatus are provided with sliding doors *t*, *u*, and at the sides of the furnace are metallic standards *x* connected by crossing stay rods *y*. The heat treatment spaces of the apparatus, that is to say, the interiors of the muffles *a* and the chamber *b* are filled by displacement with hot inert gas delivered into the spaces through the pipes *s* and *v* respectively, at points which are the highest aerostatic level of the heat treatment spaces. In order to prevent the contamination of the hot displacement gas in the interior of the muffles and chamber with gases which are reactive on the articles under treatment by leakage of the products of combustion from the flues around the muffles or of external air into the muffles and chamber a difference of pressure is maintained between the inert displacement gas in the muffles and chamber and the products of combustion in the flues.

UNDER the will of the late Sir James Inglis, a former president of the Institution of Civil Engineers, the Council have just received a legacy of £5,000, to be applied to their new building which is now in course of erection in Great George Street, Westminster. This legacy testifies to the marked interest which Sir James Inglis took in the scheme for the rebuilding of the Institution, towards the cost of which he had also, during his life-time, contributed liberally, regarding the occasion as an opportunity to promote the centralisation, and thereby the strength, of civil engineering interests throughout the British Empire.

Trade Talk.

THE COOPER-STEWART ENGINEERING COMPANY, LIMITED, have removed to 11, Broad Street, Bloomsbury, London, W.C.

SLIGHT damage has been done by fire at the North British Steel Works, Penistone Road, Sheffield, of Mr. George Clark.

A FIRE occurred at the Dalmarnock Ironworks, Glasgow, of Sir William Arrol & Company, Limited, recently, doing considerable damage.

MR. ARTHUR MUSKER, 1, Northumberland Avenue, London, W.C., has removed to 11, Victoria Street, Westminster, London, S.W.

THE WADE ENGINEERING COMPANY, LIMITED, is being wound up voluntarily with Mr. S. Colvin, 6, Castle Street, Liverpool, as liquidator.

W. K. & C. PEACE, LIMITED, of the Eagle Works, Sheffield, have been elected members of the British Chamber of Commerce in Paris.

HEAVY damage was done on July 13 by fire at the steel works of W. K. & C. Peace, Limited, Eagle Works, Mowbray Street, Sheffield.

THE HOLMES ENGINE COMPANY, LIMITED, is being wound up voluntarily, with Mr. J. Myers, 65, London Wall, London, E.C., as liquidator.

THE GLOBE PNEUMATIC ENGINEERING COMPANY, LIMITED, 150, Queen Victoria Street, London, E.C., have removed to 1, Victoria Street, Westminster, S.W.

THE business of J. & R. Houston, Limited, engineers and ironfounders, Inglestone Street, Greenock, has been purchased by Mr. John Kerr, of Greenock.

THE WELIN DAVIT AND ENGINEERING COMPANY, LIMITED, 5, Lloyd's Avenue, London, E.C., have established a branch at 112, Fenchurch Street, E.C.

THE SCOTTISH TUBE COMPANY, LIMITED, of 5, Wellington Street, Glasgow, have informed us that their London office will in future be at 54, Old Broad Street, E.C.

THE NEW-CASTLE ENGINEERING COMPANY, of Leadenhall House, London, E.C., have been appointed British agents for the J. A. Maffei Locomotive Works, Munich.

MR. GEORGE ELLISON, engineer, of the Victoria Works, 17, Warstone Lane, Birmingham, is establishing additional works at 14-17, Summer Hill Street, Birmingham.

MR. E. J. CROSIER, trading as Crosier & Company, engineers and merchants, 2, Collingwood Street, Newcastle-on-Tyne, has paid a second dividend of 6d. in the £.

THE business of the Bateman Machine Tool Company, Limited, has been acquired by Messrs. Ward, Haggas & Smith, of the Eastwood Tool Works, Keighley.

AN office has been opened at 19, Saracen's Head Chambers, Snow Hill, London, E.C., by Mr. William Hall, crucible steel and tool manufacturer, of Alma Works, Sheffield.

MESSRS. W. J. ROSE & E. B. PARKIN, carrying on business as brass founders, at 24, Great Wilson Street, Leeds, under the style of Rose & Parkin, have dissolved partnership.

THE Linlithgow Dean of Guild Court has passed plans for a new factory to be erected at Linlithgow by Messrs. A. Newlands & Sons, engineers and agricultural implement makers.

THE partnership heretofore subsisting between Messrs. F. H. Nixon and F. P. L. Mannock, carrying on business as engineers at 1, Victoria Street, Westminster, London, S.W., under the style of Nixon & Mannock, has been dissolved.

THE partnership which has for some time past been carried on by Messrs. W. W. Bateman, E. G. Brown and C. L. Oliver, under the style of the Chesterfield Engineering Company at Queen's Park Road, Chesterfield, has been dissolved.

BRINJES & GOODWIN, LIMITED, Whitechapel Engine Works, Fieldgate Street, London, E., have acquired the business of Wright, Clark & Wallis, Limited, engi-

neers, Southwark Bridge Road, London, S.E. The business has been removed to the Whitechapel Works.

MARPLE & GILLOTT, LIMITED, of Sheffield, Newcastle, Birmingham, etc., have now opened an extension of their business in London. This branch, which is situated at Sufferance Wharf, Woolwich, S.E., will be under the supervision of Mr. Ernest W. Moseley.

THE Birmingham Watch Committee have given the necessary statutory authority to certain police constables to visit periodically and inspect premises occupied by dealers in old metals. The law also allows such constables to examine the books without the usual search warrant.

THE MIDLAND EXPANDED METAL COMPANY have acquired two and a-half acres of land at Dudley Port for their works. The site is that formerly occupied by Messrs. Onions' blastfurnaces, near the London and North-Western Railway Station. The company propose to erect works, where they will employ about 100 men.

AT a recent meeting of the shareholders of Corbyns Hall Iron and Steel Works, Limited, held at 36, Waterloo Street, Birmingham, the following resolution was duly passed:—"That the company be wound up voluntarily, and that William Benjamin Tounsend, of 27, Old Jewry, London, E.C., accountant, be and he is hereby appointed liquidator for the purposes of such winding-up."

THE Manchester Engineers' Club has now been formed, and the following committee has been elected:—Messrs. D. Adamson, H. N. Allott, A. E. L. Chorlton, R. H. Clayton, Wm. Cramp, DR. G. J. Fowler, J. Frith, G. Hughes, G. Layton, F. Nasmyth, S. L. Pearce, and J. H. Stubbs. Mr. A. L. Green has been elected secretary (pro. tem.), and the applications for membership have reached 500.

THE AKTIEBOLAGET AXEL CHRISTIERNSSON, of Stockholm, Sweden, has lately opened a branch office for foundry machinery and supplies in Moscow, Russia, and would like to obtain catalogues and price lists of all kinds of foundry equipment and pattern-making supplies from English and American manufacturers. The address of the Moscow office is: Actien Gesellschaft Axel Christiernsson, Mjasnitzkaja, 15, Moscow.

SEVERAL of the disused ironworks sites and warehouses in Wolverhampton have been purchased. A new company has acquired the site of the Osier Bed Works, previously belonging to J. Lysaght, Limited, for the manufacture of iron and steel. The ironfoundry of Messrs. Thomas Bridges & Sons has been purchased by Messrs. John E. Perry & Sons, Devonshire Chambers, Lichfield Street, Wolverhampton, and will, we understand, be converted into a central warehouse for the convenient carrying on of their business. The Griffin Works, formerly owned by Messrs. W. Edwards & Son, edge-tool makers, have been bought by Messrs. Vaughan & Baxter, of Willenhall.

A SITTING of the London Bankruptcy Court was held on July 3, before Mr. Registrar Giffard, for the public examination of Captain Augustus W. Byron, Hyde Park Corner, W. The statement of affairs showed liabilities £87,772 (unsecured £62,729), and assets nil. Replying to the Senior Official Receiver, the debtor stated that in 1897 he acquired the British patents for the manufacture of weldless steel tubes. He next promoted the Universal Weldless Steel Tubes (Ehrhardt's Patent) Company, Limited. The company was not a success, and subsequently he promoted the Universal Tube Company, Limited, of which he acted as the managing director for a time. The examination was concluded.

THE CANADIAN-BRITISH ENGINEERING COMPANY have this month offered for subscription 100,000 7 per cent. preferred ordinary shares of £1 each. The shares are entitled to a non-cumulative preferential dividend of 7 per cent. per annum and to 50 per cent. of the surplus profits available for distribution. The nominal capital is £205,000, in 200,000 preferred shares of £1 each and 100,000 deferred shares of 1s. each. The object of the company is to carry on the business of engineering supplies and construction in Canada. Sole agencies have been obtained by the vendors, and are passed on to the company, for the products of such well-known firms as Sir W. G. Armstrong, Whitworth & Company, Limited, Cammell, Laird & Company, Limited, Dorman, Long & Company, Limited, the Power Gas Corporation, Ransomes, Sims & Jeffries, Limited, the Sandycroft Foundry Company, Limited, and Willans & Robinson, Limited.

UNDER the compulsory winding-up of Lindsay, Neal & Company, Limited, Paddington Iron Works, 15, North Wharf, Paddington, London, W., ironfounders and constructional engineers, the Official Receiver has now issued to the creditors and the shareholders a summary of the statement of affairs, together with his observations upon the case. The summary discloses liabilities, £28,818 15s., of which £19,487 2s. 6d. are returned as expected to rank, and estimated gross assets £9,312 4s. 10d. After payment, however, of the preferential claims, and also of the loans or debenture bonds, the latter of which total £7,837 10s. 4d., the sum of only £1,230 4s. 7d. is available to meet the claims of the unsecured creditors. These creditors accordingly have to face a deficiency of £18,256 17s. 11d., whilst with regard to the shareholders a total deficiency of £39,246 17s. 11d. is shown. The Official Receiver reports that the winding-up order was made on April 17 last upon a creditor's petition presented on April 3. The statement of affairs was submitted by Mr. Bernard Egerton Holland, and has been concurred in by Mr. Alfred Neal. No independent valuation was made at the time that the company was formed, but Mr. Holland states that the assets were valued in 1891, when he was joined in partnership by Mr. Neal, and that a proper amount was written off for depreciation. The purchase price was based on a balance-sheet prepared as at December 31, 1895, according to which the assets, apart from goodwill, amounted to £23,479 and the liabilities to £22,297, including the sum of £19,406 for cash advanced and interest. It will thus be seen that the amount paid for the goodwill of the business was £19,768.

APPLICATIONS were invited last month for £300,000 5 per cent. redeemable first mortgage debenture stock at 95 per cent., redeemable at par not later than December 31, 1934, and 150,000 6 per cent. cumulative participating preference shares of £1 each at par of the Scottish Iron and Steel Company, Limited. The Company has a share capital of £750,000 divided as follows: £300,000 5 per cent. redeemable first mortgage debenture stock (now offered), 300,000 6 per cent. cumulative and participating preference shares of £1 each, and 450,000 ordinary shares of £1 each. The vendors are taking 150,000 preference shares and the 450,000 ordinary shares in part payment of the purchase price, which is £956,508. The remaining 150,000 preference shares were offered to the public. The Scottish Iron and Steel Company, Limited, whose assets are valued at upwards of £1,000,000, has been formed for the purpose of acquiring, amalgamating and working as one concern the businesses of 13 malleable iron and steel manufacturers in Scotland. The following are the firms amalgamated:—Archibald Baird & Son, Limited, Cairnhill Iron Works, Coatbridge; Downs & Jardine, Coats Iron Works, Coatbridge; Thomas Ellis, Limited, North British Iron Works, Coatbridge; Glencairn Iron and Steel Company, Limited, Glencairn Iron Works, Motherwell; C. F. MacLaren & Company, Stenton Iron Works, Wishaw; Hugh Martin & Sons, Coatbridge Iron Works, Coatbridge; A. & T. Miller, Globe Iron Works, Motherwell; John Spencer (Coatbridge), Limited, Phoenix Iron Works and Drumpellier Iron Works, Coatbridge; William Tudhope & Son, Limited, Crown Iron Works, Coatbridge; The Victoria Iron and Steel Company, Limited, Victoria Iron Works, Coatbridge; Waverley Iron and Steel Company, Limited, Waverley Iron Works and Rochsolloch Iron Works, Coatbridge; Wylie & Company, Clifton Iron Works, Coatbridge; and the Woodside Steel and Iron Company, Limited, Koodside Iron Works, Coatbridge.

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COLONIES, AND FOREIGN GOVERNMENTS.

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Evans's Rapid.

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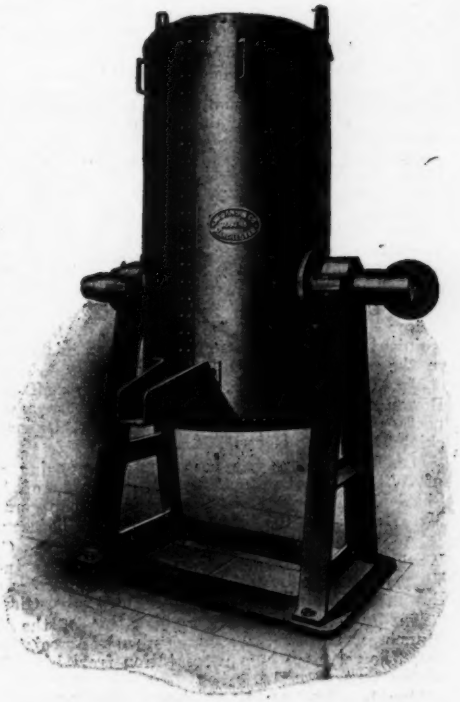

James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

Personal.

Sir Percy Girouard has been elected a director of Sir W. G. Armstrong, Whitworth & Company, Limited.

The late Mr. W. C. Martin, of Messrs. W. C. Martin & Company, engineers, left personal estate valued at £8,359.

Mr. J. M. Kadisch and Mr. A. Lord have been elected directors of the Selson Engineering Company, Limited.

Sir Maurice Fitzmaurice, chief engineer to the London County Council, will resign that position at the end of the year.

Mr. A. Sladden, secretary of the South Durham Steel and Iron Company, Limited, has been made a J.P. for Stockton-on-Tees.

Mr. Robert English has been elected chairman of Fraser and Chalmers, Limited, in succession to the late Sir Julius Wernher.

The personal estate of the late Mr. W. Wallace, of John Wallace & Sons, engineers, 7, Graham Square, Glasgow, has been valued at £45,315.

The late Mr. Duncan M'Pherson, ironfounder, of Camphill, Bearsden, Dumbarton, left personal estate in the United Kingdom valued at £2,955.

Mr. G. H. Wright, secretary of the Birmingham Chamber of Commerce, has been appointed secretary of the Edge Tool Manufacturers' Association.

The gross value of the estate of the late Mr. Robert Hudson, of the Gildersome Foundry, Gildersome, near Leeds, is £121,389, with net personalty £44,246.

The late Mr. J. H. Turner, a director of P. & W. MacLellan, Limited, Clutha Works, Plantation, Glasgow, left personal estate valued at £17,630.

The value of the personal estate of the late Mr. D. A. Graham, of Messrs. Auld & Sons, engineers and ironfounders, Glasgow, is £3,631, of which £3,294 is in Scotland.

Mr. R. J. Milbourne, for a long time associated with C. & W. Walker, Limited, has been appointed general manager of the Company in place of Mr. H. Wright, resigned.

The late Mr. J. Dodd, chairman of Platt Bros. & Company, Limited, of Oldham, left estate of the gross value of £228,100, of which the net personalty has been sworn at £222,380.

Mr. C. W. Kayser, managing director of Kayser, Ellison, & Company, Limited, Sheffield, has been the recipient of a presentation from the officials and men on the occasion of his marriage.

Mr. Wilson Harvey, formerly on the staff of David Rowan and Company, of Glasgow, has been admitted a partner in the firm of McKie & Baxter, engineers and shipbuilders, of Govan, Glasgow.

Mr. H. C. Else has been elected managing director of William Cooke & Company, Limited, of Tinsley, Sheffield. The office absorbs the dual managerships of Mr. Else and of the late Mr. John H. Wilkinson.

Messrs. McKie & Baxter, engineers, Copland Works, Govan, Glasgow, have assumed as partner Mr. Wilson Harvey, formerly on the staff of Messrs. David Rowan & Company, engineers, Elliot Street, Glasgow.

Mr. J. King, the retiring president of the Scottish Branch of the British Foundrymen's Association, has been the recipient of a presentation from his colleagues of the first council.

The late Mr. M. W. Swinburne, of Messrs. W. M. Swinburne & Sons, brassfounders, engineers, and coppersmiths, of Wallsend, left estate of the gross value of £26,460 6s. 6d., of which the net personalty has been sworn at £23,348 5s. 8d.

A general committee, representing the engineering societies of the British Empire and of the United States of America, has been formed to carry into effect a proposal for the erection in Westminster Abbey of a memorial window to the late Lord Kelvin.

In succession to the late Sir John G. N. Alleyne, Bart., Sir Gilbert H. Claughton, Bart., late chief mineral agent to the Earl of Dudley, and chairman of the London and North-Western Railway, has been elected a member of the Council of the Iron and Steel Institute.

The late Mr. W. E. Hipkins, managing director of W. & T. Avery, Limited, a director of the Birmingham Small Arms, Limited, and of John & Edwin Wright, Limited, left estate of the gross value of £37,728 9s. 3d., of which the net personalty has been sworn at £27,046 2s. 4d.

New Companies.

The Harris Furnace Company, Limited.—Capital £5,000 in £1 shares.

Harper Syndicate, Limited.—Capital £2,500 in 2s. shares, to carry on the business of engineers, etc.

Peter Harvey, Limited.—Capital £2,000 in £1 shares, to carry on the business of general engineers, etc.

Whitworth & Jones, Limited.—Capital £3,000 in £1 shares (1,000 deferred), to carry on the business of metallurgists, etc.

H. Gibbons & Company, Limited.—Capital £6,000 in £1 shares, to carry on the business of engineers. Registered office: Hungerford.

Castlehouse & Turner, Limited.—Capital £2,000 in £1 shares, to carry on the business of engineers. Registered office: 36, Park Square, Leeds.

Wragg & Biggin, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers, etc. Registered office: 83, Sussex Street, Sheffield.

Canadian-British Engineering Company, Limited.—Capital £205,000 in 200,000 7 per cent. preferred ordinary shares of £1, and 100,000 deferred of 1s.

Allan-Clayton, Limited.—£2,000 in £1 shares to carry on the business of tool makers, etc. Registered office: 71-6, Charlotte Street, Birmingham.

Dilworth & Carr, Limited.—Capital £10,000 in £1 £1 shares, to carry on the business of ironfounders, etc. Registered office: Bow Lane, Preston, Lancs.

G.N., Limited.—Capital £3,000 in £1 shares, to take over the business of engineers, etc., carried on at Elm Works, The Burroughs, Hendon, N.W., as Godfrey and Nash and G.N.

Scottish Iron and Steel Company, Limited.—Capital £750,000 in 300,000 preference and 450,000 ordinary shares of £1 each. Registered office: 209, West George Street, Glasgow.

Ferman & Company, Limited.—Capital £5,000 in 1,250 "A" shares of £1, and 75,000 "B" of 1s., to carry on the business of ironfounders, etc. Registered office: 3, London Wall Buildings, E.C.

H. Gibbons & Company, Limited.—Capital £6,000 in £1 shares, to take over the business of an engineer, founder, and smith carried on by H. W. Gibbons at Hungerford, Berks., as Gibbons & Son.

Brunton's (Sudbury), Limited.—Capital £5,300 in 5,000 preference shares of £1, and 6,000 ordinary of 1s. to carry on the business of engineers, etc. Registered office: Stour Valley Ironworks, Sudbury, Suffolk.

Willow Bridge Engineering Company, Limited.—Capital £500 in £1 shares, to carry on the business of engineers, etc., and to acquire the goodwill and assets of the Precision Tool Company, of Leicester. Registered office: 172, Willow Street, Leicester.

Deptford Engineering Company, Limited.—Capital £1,000 in £1 shares, to take over the business of a brassfounder and pattern maker carried on by N. P. Woodward, of the Railway Arches, High Street, Deptford, S.E., as the Deptford Engineering Company. Private Company.

PURE METALS

and ALLOYS. FREE from CARBON.

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Works: 210a, Bow Road, E.

ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

METALS.	End July, 1912.	End July, 1911.
Iron—Scotch pig warrants ton	*64/10½	*52/9
—Middlesbro' warrants ... ton	59/4	46/11½
—W.C. M/nos Bessemer ... ton	77/6	63/0
—Stock, Scotch ... ...tons	1,000	1,000
Copper—Chili bars, GMB ton	£78 2 6	£56 5 0
—Stock, Europe and afloat tons	—	—
Tin—English ingots ... ton	£210 0 0	£193 0 0
—Straits ... ... ton	£204 15 0	£190 0 0
—Stock, London, Holland, U.S.A., and afloat ...tons	—	—
Lead—English pig ... ton	£19 7 6	£14 3 9
Spelter—Ord. Silesian ... ton	£26 0 0	£25 1 3
Quicksilver (75lb)... bottle	£8 10 0	£9 0 0
Antimony—Regulus . ton	£27 10 0 £28 10 0	£23 10 0
Aluminium—Ingot ... ton	£80 0 0	

* Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	6 15 0	to	7 0 0
Pipes, 1½ to 2½ in.	5 12 6	to	6 0 0
,, 3 to 4 in.	5 7 6	to	5 10 0
,, 5 to 8 in.	5 5 0	to	5 7 6
,, 10 to 16 in.	5 5 0	to	5 7 6
,, 18 to 24 in.	5 5 0	to	5 7 6
Chairs	3 17 6	to	4 0 0
Floor plates (open sand)	3 10 0	to	3 12 6

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows: Heavy wrought (mixed), £2 10s. 0d.; light wrought, £1 5s. 0d.; heavy cast, £2 10s. 0d.; all per ton, f.o.b., London. Copper (clean), £70 10s. 0d.; brass (clean), £45 10s. 0d.; lead (usual draft), £17 10s. 0d.; zinc, £20 10s. 0d.; all per ton delivered merchant's yard.

Deaths.

THE death is announced of Mr. C. Bevitt, of Messrs. John Bevitt & Son, ironfounders, Pontefract, Yorks.

MR. C. H. BAGSHAW, of J. Bagshaw & Sons, Limited, engineers and ironfounders, of Batley, died recently, at the age of 59 years.

MR. C. CRICHTON, of C. & H. Crichton, Limited, Huskisson Engine Works, Derby Road, Liverpool, died recently, at the age of 63 years.

MR. F. F. BIGGS, for many years in business as an engineer and founder at St. Ives, Hunts, died recently at the age of 87.

MR. E. AULT, of Messrs. Shone & Ault, consulting engineers, 47, Victoria Street, Westminster, London, S.W., and Wrexham, died recently, in India.

MR. THOMAS BROWN, of The Poplars, Marlborough Road, Moor Oaks, Sheffield, died recently in his 82nd year. In the sixties, Mr. Brown went to Sheffield to join the firm of Messrs. Bedford, Burys & Company. Shortly afterwards the concern was converted into a limited company, and Mr. Brown was appointed secretary. In 1876, on the death of Mr. W. T. Burys, Mr. Brown also became manager, and he held the dual position of secretary and manager until October, 1907, when he retired from active participation in the business.

MR. ROBERT HUDSON, J.P., of Kirkintilloch, died on June 20. Mr. Hudson was born in Falkirk 68 years ago, and served his apprenticeship as a fitter there. Proceeding to Glasgow, he was for some time in the Sun and Saracen Foundries. In 1880, along with Messrs. Jackson and Brown, he started the iron foundry at Kirkintilloch. The business expanded till it was necessary to convert it into a limited liability company, under the style of the Lion Foundry Company, Limited. Mr. Hudson became chairman and managing director, and held these positions till the time of his death.

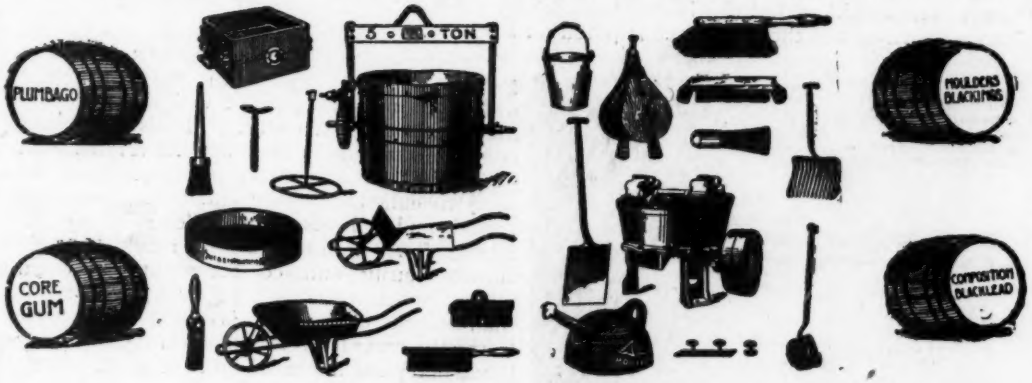
BLOFIL
THE
IRON CEMENT
(Quick or slow setting grades)
IS
THE CHEAPEST
AND
MOST RELIABLE
for all purposes.
Unaffected by oil, steam, or water.
Sole manufacturers—
RUDD & OWEN
(DEPT. I)
Telegrams "Therpinene" Hull.
HULL
Telephone National 1223

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



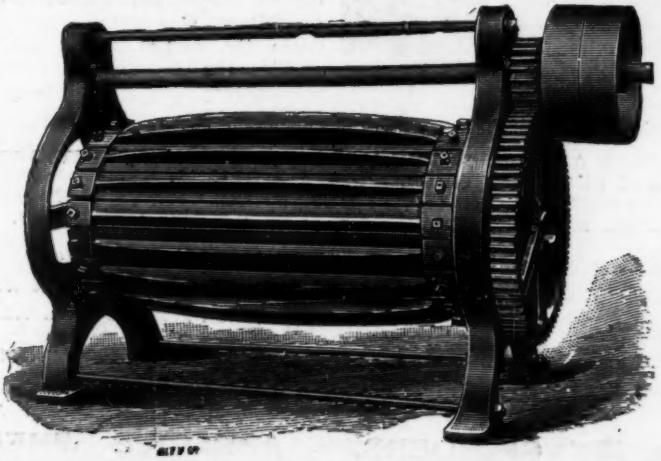
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

Plate Moulding with Snap Flasks . .

is used extensively for dealing with light castings in all departments of the foundry trade. It is without question a very rapid method of moulding, and taken in conjunction with the fact that the snap flask does away with moulding boxes it is not surprising that the system is growing in favour. In point of output many power Moulding Machines can show an advantage over plate moulding, but this is over-balanced by the cost of the necessary boxes, the maintenance expenses and the floor space required for storing them.

¶ In our **BOXLESS HYDRAULIC MOULDING MACHINE** we have the snap flask or boxless system combined with a power ramming moulding machine. It is the most complete machine in existence, for it rams both halves of the mould simultaneously, draws the pattern, cuts the runner and gates, closes the mould, and delivers it ready for receiving the metal. ¶ As both halves of the mould are made simultaneously and compressed to an equal extent, much truer and better castings result than when each half is made separately. Correctly located pins and holes in the moulding boxes and pattern frames ensure accurate closing and prevent overshut castings.

¶ The rate of production is such that no man with a plate and a snap flask can possibly compete. 200 moulds a day is quite ordinary and, in some cases, the rate of production with two men amounts to 400 moulds in eight hours.

¶ One firm to whom we have supplied several of these machines is obtaining four times the output they were formerly getting by plate moulding. ¶ Another is getting two and a half times the output, whilst a third is obtaining double the quantity of moulds they were previously getting from pneumatic machines.

¶ The following is some of the work that the machine is doing :—

SEWING MACHINE ARMS. FURNACE BARS. BOILER DOORS AND FITTINGS.
STOVE PLATE CASTINGS. AIR BRICKS. BRACKETS.
COTTON AND SPINNING MACHINE FITTINGS. MANGLE PARTS. COLLIERY TUB WHEELS.
AGRICULTURAL MACHINE FITTINGS LAWN MOWER FITTINGS. ETC., ETC.

The machine will not make any and every casting, but if you will send us sample castings or drawings of your work we will tell you what it will do, or if you would like to see one of our representatives, we will arrange for a visit.

THE QUICKER YOU ACT THE SOONER WILL THE SAVING BEGIN.—WRITE TO-DAY.

With our 15 different types of Moulding Machines we cover the requirements of any foundry.

EMERY GRINDERS. ABRASIVE WHEELS.

THE LONDON EMERY WORKS Co., PARK WORKS,
TOTTENHAM, LONDON, N.

THE BUYER'S GUIDE

Addresses and further information will be found by reference to the Firm's Advertisement.

Abrasive Wheels.
Evans, J. & Co.
London Emery Works
Jackman, J. W., & Co. Ltd.

Air Compressors.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Electrically Driven).
Jackman, J. W., & Co., Ltd.
Marshall & Co. Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Steam).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Belt).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Aluminium.
British Aluminium Co, Ltd.

Annealing.
Evans, J. & Co.
Phillips, J. W. & C. J.

Ash Crushing and Washing Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Barrels (Tumbling).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Hall, Charles, & Co.
Hooker, Peter, Ltd.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.
Standard Sand-blast Machine Co., ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Barrows.
F. Braby & Co., Ltd.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co. Ltd.

Bellows.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Durrans, Jas., & Sons.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Blacklead.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Blowers.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Dempster, R. & J., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Keith, J., & Blackman, Co., Ltd.
London Emery Works Co.

Blowers—*cont*
Marshall, H. P., & Co., Ltd.
Phillips, J. W. & C. J.
Samuelson & Co., Ltd.
Thwaites Bros., Ltd.
Ward, T. W., Ltd.

Buffing and Polishing Machines.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.

Casting Cleaners.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Cement.
Dyson, J. & J.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Lowood, J. Grayson, & Co., Ld.
Marshall & Co., Horace P.
Metalline Cement Co.
Olsen, Wm.
Plasti-Kion Co.
Rudd & Owen
Silent Machine and Eng Co.

Chaplets and Studs.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Motherwell, Wm., & Co.
Olsen, Wm.
Wilkinson, T., & Co., Ltd.

Charcoal.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J W., & Co., Ltd.
Mansergh, T. E.
Walker, I. & I.

Charging Platforms.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Thwaites Bros., Ltd.

Coal Dust.
Cumming, Wm., & Co., Ltd.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles & Co
Jackman, J. W., & Co., Ltd.
Mansergh, T. E.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Coke (Foundry).
Elders Navigation Collieries.

Coke Breakers.
Evans, J., & Co
Jackman, J. W. & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W., & C. J.

Core Boxes.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.

Core Compounds.
Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.
Wilkinson, Thos. & Co.

Core Gums.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W. & Co., Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd

Core Making Machines.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co
Marshall, H. P. & Co.
Phillips, J. W. & C. J.

Core Ovens.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J. & Co.
Hislop, R. & G.
Jackman, J. W. & Co., Ltd.
Jones & Attwood, Ltd.
London Emery Works Co.
Phillips, J. W. & C. J.
Portway, C. & Son.

Core Ropes.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Wilkinson, T. & Co.

Core Vents.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Cranes.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J. & Co.
Jackman, J. W., & Co., Ltd.
Ward, T. W., Ltd.

Crucibles.
Evans, J. & Co.
Hall, Charles, & Co.
Olsen, Wm.

Crucible Furnaces.
Alldays & Onions Pneumatic Eng. Co., Ltd,
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.

Crucible Furnaces (Lift-out)
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Phillips, J. W. & C. J.

Crucible Furnaces (Tilting)
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Crushing Mills.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.

Cupolas.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T. & Son.
Derby Boiler Co., Ltd.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.
Marshall, H. P. & Co.
Phillips, J W. & C. J.
Thwaites Bros., Ltd.

Cupola Linings.
Evans, J., & Co.
Hall, Charles & Co
Harris & Pearson.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.

Emery Grinders.
Alldays & Onion Pneumatic Eng. Co., Ltd.
Davis, T., & Sons.
Evans, J., & Co.,
Hall, Charles & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.

Emery and Glass Cloth and Glass Paper.
London Emery Works Co.

Emery Wheels.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J. & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Mitchells Emery Wheel Co.

Facings.
Evans, J. & Co.
Olsen, William

Fans.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T. & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Jenkins, W. J. & Co., Ltd.
Keith, James, & Blackman Co., Ltd
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

Firebricks.
Durrans, J. & Sons.
Dyson, J. & J.
Evans, J. & Co.
Fyfe & Co., J. R.
Harris & Pearson.
Jackman, J. W., & Co., Ltd.
King Bros.
Lowood, J. Grayson, & Co., Ltd.
Pearson, E. J. & J.

Foundry Blacking.
Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Olsen, Wm.
Walker, I. & I.
Wilkinson, Thos. & Co., Ltd.

Foundry Brushes.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, C., & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Phillips, J. W. & C. J.

Foundry Ladles.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Derby Boiler Co., Ltd.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
McNeil, Chas.
Phillips, J. W. & C J.
Thwaites Bros. Ltd.

THE BUYER'S GUIDE.—*Continued.*

Foundry Rattlers or Fettling Drums.
Alldays & Onions
Davies, T., & Son
Durrans, J., & Sons
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co.
London, Emery Works Co.
Marshall & Co., Horace
Phillips, J. W. & C. J.

Foundry Sand.
Standard Sand Co., Ltd.
Dyson, J. & J.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Wilkinson & Co., Thos., Ltd.
Williams, J. (Birmingham Sand), Ltd.

Foundry Specialists.
Naish & Croft.

Furnaces (Annealing).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J. & Co.
Hislop, R. & G.
Keith, James, & Blackman, Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Furnaces (Brass).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Furnaces (Melting).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Ground Gannister.
Durrans, J., & Sons.
Dyson, J. & J.
Evans, J., & Co.
Lowood, J. Grayson, & Co.
Walker, I. & I.

Grinding Machines and Tools.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.

Hammers (Steam).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Thwaites Bros., Ltd.

Hay Band Spinning Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall &Co., Horace P.

Hoists.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co., Ltd.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

Loam and Sand Mills.
Davies, T., & Son.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall & Co., Horace P.
Ward, T. W., Ltd.

Melting Furnaces (Oil fired).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Mould Driers.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Moulding Machines.
Adjustable Moulding Machine Co.
Britannia Foundry Co.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.
Pickles, James.
Pneumatic Engineering Appliances Co., Ltd.
Samuelson & Co., Ltd.
Stewart, Duncan & Co., Ltd.
Universal System of Machine Moulding and Machinery Co. Ltd.
Whittaker, Wm., & Sons, Ltd.

Moulding Machines (Hand and Power).
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Pickles, James.

Pig Breakers.
Evans, J., & Co.
Jackman J. W., & Co., Ltd.
London Emery Works Co.

Pig-Iron.
Bradley & Sons, T. & I., Ltd.
Frodsir Iron and Steel Co., Ltd., The
Goldendale Iron Co., Ltd.

Plumbago.
Cumming, Wm. & Co., Ltd.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Pneumatic Tools.
Jackman, J. W., & Co., Ltd.
J. Macdonald & Son, Ltd.
Marshall, H. P. & Co.

Polishing Sundries.
Evans J. & Co.
London Emery Works Co.

Publications.
Eagland & Co., Ltd.
Griffin & Co., C.

Pyrometers.
Alldays & Onions, Ltd.
Phillips, J. W. & C. J.

Recording Gauges.
Evans, J. & Co.
Jackman, J. W., & Co., Ltd.
Phillips, J. W. & C. J.

Riddles.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Wilkinson, Thos. & Co., Ltd.

Sand Blast Apparatus.
Hooper, Peter, Ltd.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Phillips, J. W. & C. J.
Standard Sand-Blast Machine Co., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Sand Driers.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Phillips, J. W. & C. J.

Sand Grinding Mills.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.

Sand Mixers.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Sand Riddling, Separating and Sifting Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P. & Co., Ltd.
Pneumatic Engineering Appliances Co., Ltd.

Sieves.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.

Smiths' Hearths.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Keith, James, & Blackman, Co., Ltd.
Marshall & Co., H. P., Ltd.
Samuelson & Co., Ltd.
Thwaites Bros., Ltd.

Steel Moulders' Composition.
Dyson, J. & J.
Evans, J., & Co.
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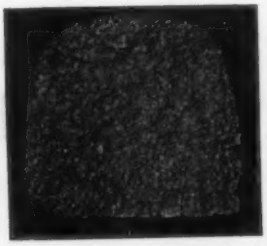
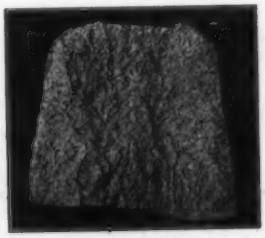

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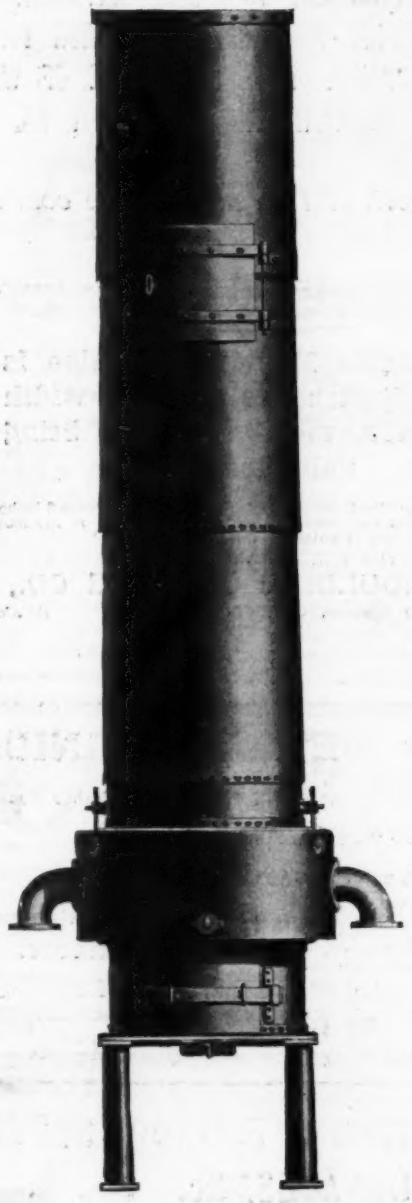

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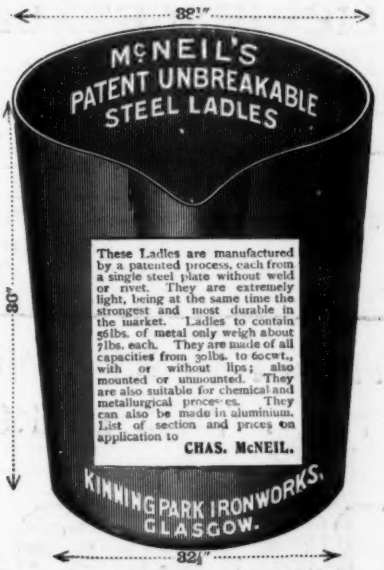
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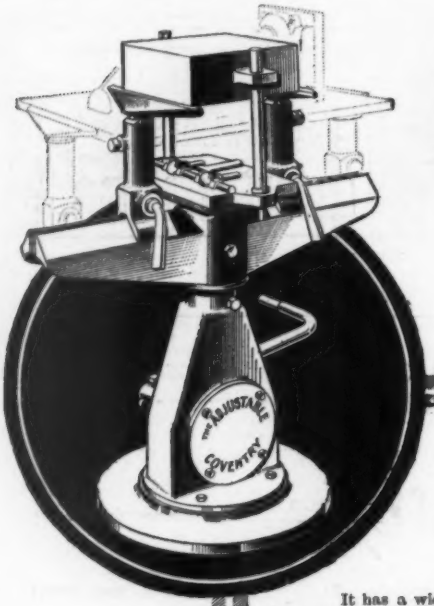

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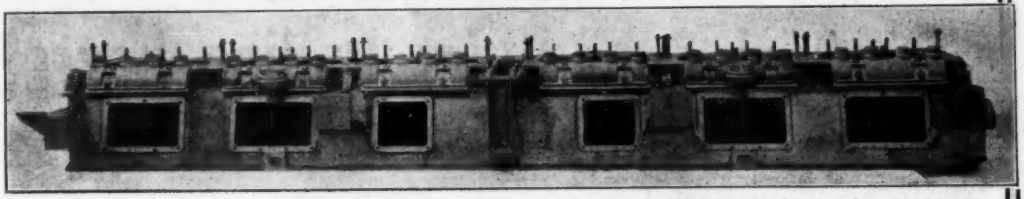

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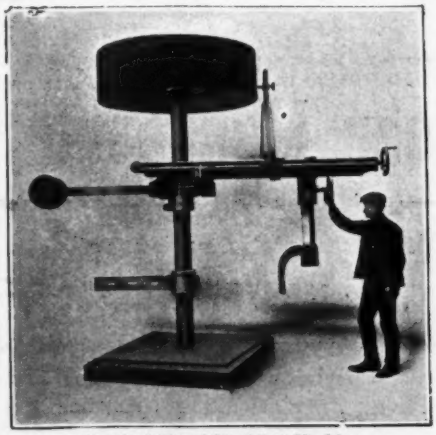

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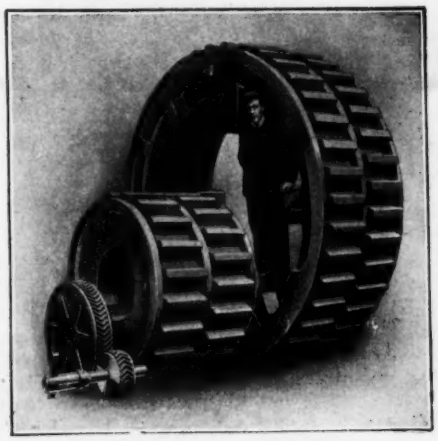

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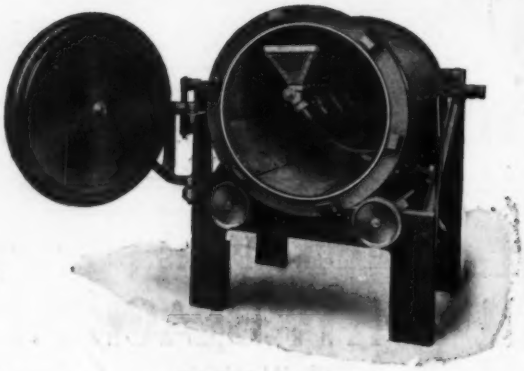

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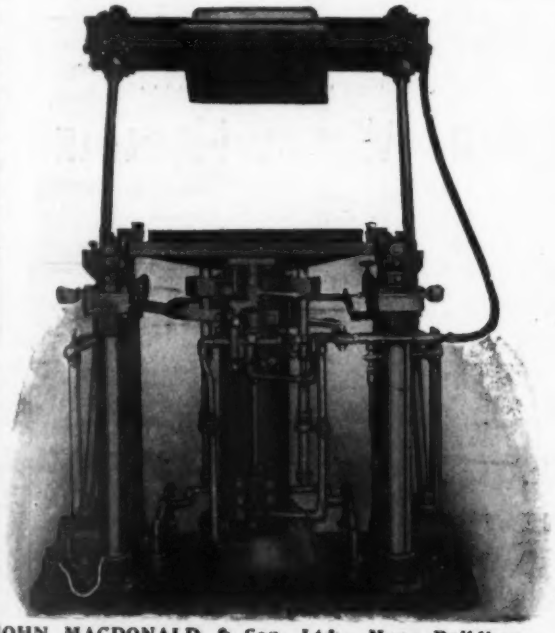

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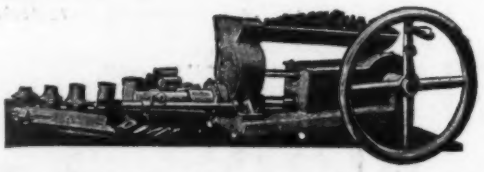

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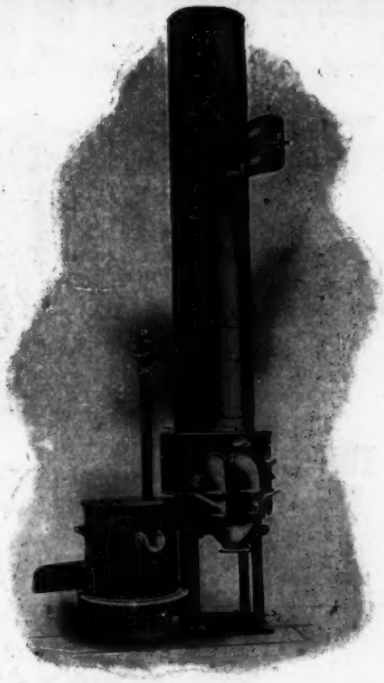

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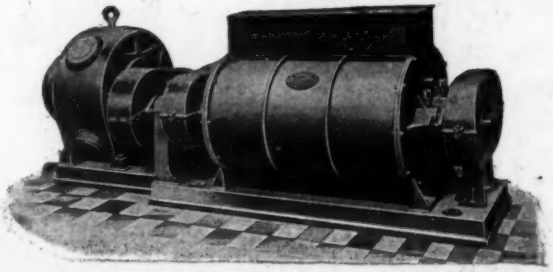

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